

**RULES AND SYLLABI
OF THE
INSTITUTION EXAMINATIONS**
(Effective from Summer 2005 Examination as per Revised Syllabi)



The Institution of Engineers (India)
8 Gokhale Road, Kolkata 700 020

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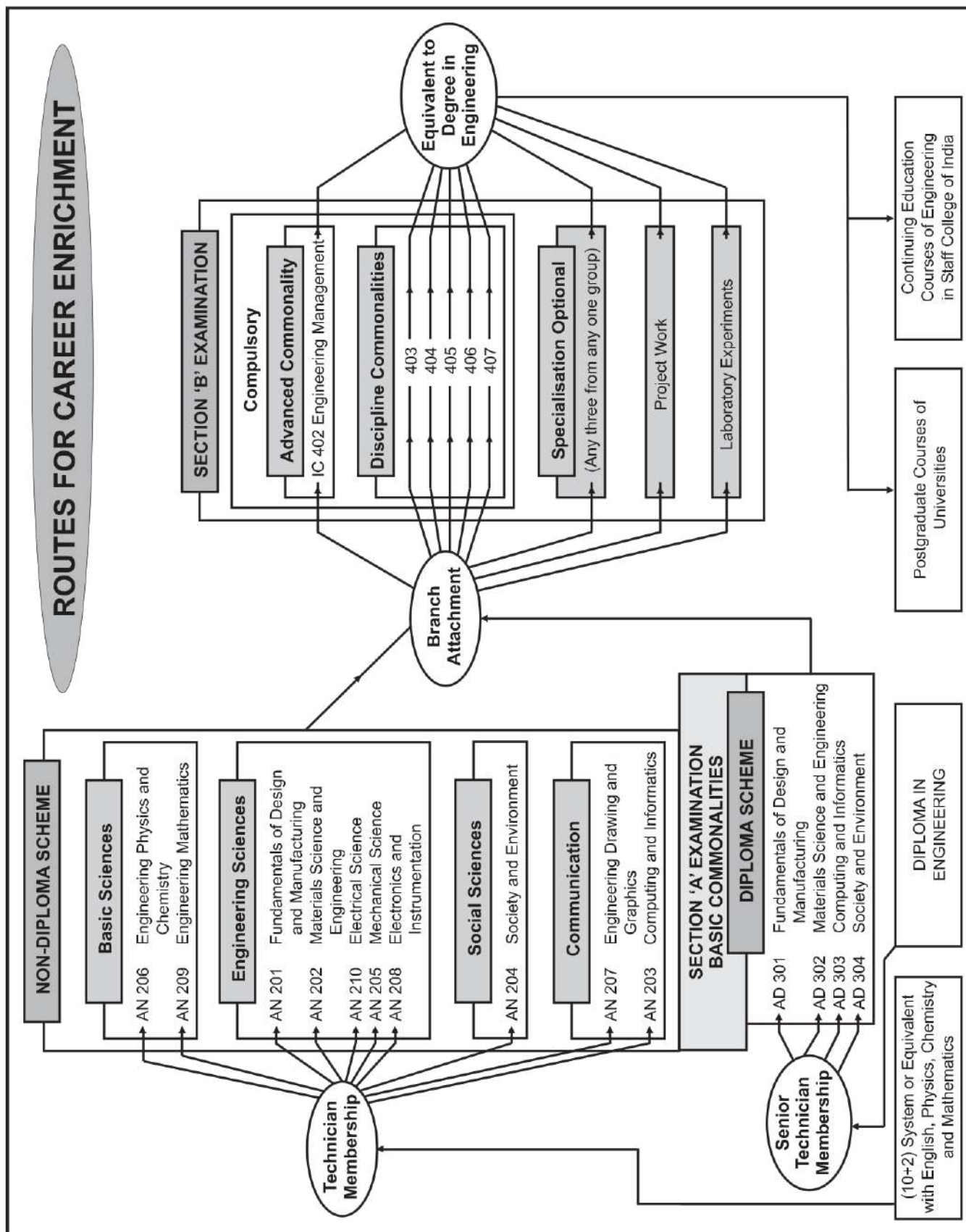
PREAMBLE

The Institution of Engineers (India), established in 1920, is a pioneer in the field of nonformal education in engineering, having framed its course structure as far back as in 1924. Now the Institution, with its 15 engineering divisions and having well established infrastructure, has taken the lead to frame practice-oriented non-formal engineering courses for the country as a whole. The need of the time, development of cutting edge technologies and inclusion of new emerging areas have been given due consideration. It spells out the national policy of the country in the field of engineering education—both formal and professional. The revised course structure has been worked out involving eminent academicians, technocrats and practicing engineers.

While developing the Revised Syllabi, special emphasis has been given on the following aspects :

- The course structure and the detailed syllabi have been made suitable for non-formal education in engineering.
- The structure and courses have been designed to meet the requirements of the profession in consonance with the need for developing professional competence.
- The course structures have been based on (a) basic commonalities, (b) advanced commonalities, (c) discipline commonalities, and (d) specialisation.
- As far as practicable, uniform course structure has been adopted for all engineering disciplines.
- The course have been designed to develop the competence level of the candidates primarily as hardcore engineers. This is important because the question of competence comes into account when mobility of engineers from one country to another, as is happening now, is considered.
- The course structure has provided laboratory exposure to the candidates.

For development of course structure in different engineering disciplines, requirement prescribed by AICTE, demand of industries, interest of working professionals, and future needs of the engineering profession have been kept in mind. Stress has given on the total concept—education and experience. The educational content for the prospective competent engineer to practice has been well-defined in the course structure.



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EXAMINATION RULES

SECTION A AND SECTION B EXAMINATIONS

(Any notification, changes, modifications and alterations shall normally be intimated to the members through Technicians' Journal and IEI HQS website - www.ieindia.org)

1 GENERAL INFORMATION

- 1.1 Only members of The Institution of Engineers (India) are permitted to appear at the examinations conducted by the institution in conformity with their eligibility and qualifications. Eligibility and qualifications for election as members of various classes are www.ieindia.org

- 1.2 The Institution conducts the following examinations:

Section A (Diploma Stream)

Section B in the following branches of engineering :

Chemical Engineering
Civil Engineering
Computer Science & Engineering
Electrical Engineering
Electronics and Communication Engineering
Materials and Metallurgical Engineering
Mechanical Engineering
Mining Engineering
Production Engineering
Textile Engineering

The examination in one or more of the above branches may be discontinued with prior notification. In addition to the above examinations, the Council of the Institution may introduce Section B examination in one or more of the following branches of engineering:

Aerospace Engineering
Agricultural Engineering
Architectural Engineering
Environmental Engineering
Marine Engineering

- 1.3 The Institution Examinations shall be held *twice* a year, generally in June and in December — termed as SUMMER and WINTER Examination, respectively in the schemes as may be decided by the Council. The Council may, however, change the frequency and timings, if necessary. The exact dates of examinations, the programmes thereof and the period of submission of examination application

forms shall be notified. **No information will be sent to members individually.**

- 1.4 Candidates shall be required to strictly adhere to the *Rules for Conduct of Examinations in the Examination Hall (Appendix II)* and any violation of the same shall attract penal measures, as may be decided by the Council of the Institution. The decision of the Council in all such matters shall be final and binding upon a member of the Institution.

- 1.5 The following grading system for the Institution Examinations shall be followed for all subjects of Sections A & B, laboratory experiments and project work :

Range of Marks (out of 100)	Grade Symbol	Grade Point
75-100	H	10
66-74	A	9
60-65	B	8
50-59	C	6
35-49	D	5
20-34	E	
0-19	F	

Notes:

- Only grade will be provided in individual subjects.
- In the pass grade card of Section A/ Section B Examination, apart from grade in individual subjects, GPA (Grade Point Average) will also be provided.
- For a complete pass in Section A or in Section B, **minimum GPA shall be 6.**
- Any subsequent change in the rules, as may be approved by the Council from time to time, shall be deemed to have been included in the Rules of the Institution Examinations. Each of such amendments shall be notified.

2 DETAILS OF EXAMINATIONS

2.1 SECTION A EXAMINATION

[Technician members enrolled with the Institution earlier are only eligible to apply for appearance in the Institution examination within the stipulated period. The enrollment includes registration for examination in Section A (Non-diploma)]

2.1.1 A candidate shall be required to pass in 10 (ten) subjects as given in **Appendix I**. The full marks for examination in each subject is 100 (one hundred). The duration of examination for each subject is 3 (three) hours. Detailed syllabi of prescribed subjects are given in pages 11-15.

2.1.2 A candidate shall be required to secure minimum grade 'C' in 8 (eight) subjects and grade 'D' in remaining two subjects to completely pass Section A (Non-diploma) examination within the stipulated period. Score of grade 'D' in two subjects shall only be considered in the last attempt provided the candidate secured at least grade 'C' in all the remaining 8 (eight) subjects with minimum GPA being 6. The score of grade 'D' or lower grade(s) in any subject(s) shall not be carried forward. A candidate shall be required to reappear in those subjects again.

Further, a candidate, who is not required to appear in all the 10 (ten) subjects (Ref. 2.1.1), shall have to secure minimum grade 'C' in each of the remaining subject(s) for a final pass.

2.1.3 A candidate shall not be permitted to appear in more than 4 (four) subjects in one term, including the subject(s) in which he appeared previously but could not secure minimum grade 'C'.

2.1.4 If a Technician member, after acquiring diploma level qualification, changes his membership to Senior Technician, he shall be considered, on request, as exempted to appear from Section A Examination provided he secured exemption (obtained Grade C or above with minimum GPA being 6) in four common subjects of same nomenclature in both Section A (Non-diploma) and Section A (Diploma) of revised syllabi. No pass grade card of Section A shall be issued. He shall be eligible to register for Section B, with requisite fee, with an undertaking that he shall not claim pass grade card for Section A. The CGPA shall be calculated only on the basis of Section B Examination, project work and laboratory experiments.

In case the Technician member secured exemption in one or more common subject(s) of same nomenclature in both the schemes of revised syllabi, grade in common subject(s) can be carried forward, on request, after change of his membership.

The change of membership from Technician

to Senior Technician for candidates appeared in the current examination, shall be considered only after the declaration of their result as Technician members. After declaration of result, these candidates, on their election as Senior Technician members by virtue of their diploma qualification, will not be able to appear in the immediate next examination as per rules. However, they would be eligible to get fresh six-year period from the date of election as Senior Technician member to pass the examination and also eligible to get transfer of exemptions in common subject(s), if passed as Technician members.

2.2 SECTION A (DIPLOMA STREAM) EXAMINATION

[Senior Technician members enrolled with the Institution are only eligible to apply for appearance in the Institution examination within the stipulated period. The enrolment includes registration for examination in Section A (Diploma)]

2.2.1 A candidate shall be required to pass in 4 (four) subjects as given in **Appendix I**. The full marks for examination in each subject is 100 (one hundred). The duration of examination for each subject is 3 (three) hours. Detailed syllabi of prescribed subjects are given in pages 16-17.

A candidate may be required to qualify in less number of subjects provided such a candidate, in consideration of his academic credentials, is given exemption in one or more subjects by the Institution.

2.2.2 A candidate shall be required to secure minimum grade 'C' in 3 (three) subjects and grade 'D' in remaining one subject to completely pass Section A (Diploma) examination within the stipulated period. Score of grade 'D' in one subject shall only be considered in the last attempt provided the candidate secured at least grade 'C' in all the remaining 3 (three) subjects with minimum GPA being 6. The score of grade 'D' or lower grade(s) in any subject(s) shall not be carried forward. A candidate shall be required to reappear in those subjects again.

Further, a candidate, who is not required to appear in all the 4 (four) subjects (Ref. 2.1.1), shall have to secure minimum grade 'C' in each of the remaining subject(s) for a final pass.

2.2.3 A candidate shall be permitted to appear in all 4 (four) subjects at a time in one term, including the subject(s) in which he appeared previously but could not secure minimum grade 'C'.

2.3 SECTION B EXAMINATION

Technician/ Senior Technician members enrolled with the Institution who have passed Section A of the Institution Examination or any other examination recognised by the Council as exempting therefrom

OR

Corporate members, who have passed Sections A & B of Institution Examinations in one branch of engineering or secured exemption therefrom for appearing in another branch of engineering, are only eligible to apply for appearance in the Institution examination within the stipulated period (Ref. 8.7)

Such candidates are required to register for Section B examination, immediately after declaration of result of Section A examination, as per the prescribed format (Appendix III), with requisite fee indicating their choice of (a) branch of engineering, (b) optional subjects selected.

2.3.1 A candidate shall be required to qualify in 9 (nine) subjects — 6 (six) compulsory and 3 (three) optional (**Appendix I**), except in Marine Engineering branch, where a candidate is required to pass in 10 (ten) compulsory subjects and 1 (one) optional subject, out of the two. The full marks for examination in each subject is 100 (one hundred) and the duration of examination for each subject is 3 (three) hours. Detailed syllabi for prescribed subjects are given in (pages 18-157).

Further, a candidate shall have to complete project work and also sessional work on laboratory experiments (Ref. 12 and 13). Full marks shall be 100 (one hundred) each for project work and laboratory experiments.

2.3.2 A candidate shall be required to secure minimum grade 'C' in 7 (seven) subjects and grade 'D' in remaining two subjects to completely pass Section B Examination, except in Marine Engineering branch, within the stipulated period. For Marine Engineering branch, a candidate shall be required to secure minimum grade 'C' in 9 (nine) subjects and grade 'D' in remaining two subjects to completely pass Section B examination within the stipulated period. Score of grade 'D' in

two subjects shall only be considered in the last attempt provided the candidate secured minimum grade 'C' in remaining seven subjects in any branch with minimum GPA being 6, except Marine Engineering for which minimum grade 'C' shall be required for remaining nine subjects with minimum GPA being 6. The score of grade 'D' or lower grades(s) in any subject(s) shall not be carried forward. A candidate shall be required to reappear in those subjects again.

2.3.3 A candidate shall not be permitted to appear in more than 4 (four) subjects at a time in one term, including the subject(s) in which he appeared previously but could not secure minimum grade 'C'.

2.3.4 Candidates, who wish to appear in additional branch of engineering will be exempted, on request, from appearing in those subjects of same nomenclature and syllabus in which they have secured minimum grade 'C' or 50 marks and above in the Institution examination in earlier branch. However, this facility will not be applicable to candidates having passed Section B examination in old scheme and syllabus.

2.3.5 (i) If a candidate changes the branch of engineering before completely passing in one branch, the results in relation to all the subjects he had previously appeared, if any, shall be automatically cancelled. He is required to apply afresh for registration of Section B with requisite fee (**Appendix III**).

(ii) If a candidate changes the optional subjects either within the group or from one group to other, he shall have to register afresh with requisite fee. The results in relation to all the optional subjects he had previously appeared, if any, shall automatically be cancelled, except the common subject(s) in the groups in which a candidate has secured minimum grade 'C'.

2.3.6 A candidate is eligible to apply for extra subject(s), not exceeding *four* subjects in one term, after passing Section B examination, with prescribed fee. The grade(s) secured by a candidate in extra subject(s) shall not be considered for improvement of grade(s) secured by him in earlier examinations.

3 APPLICATION FOR APPEARING IN EXAMINATION

3.1 A candidate shall be required to submit an application

in the prescribed form to the Headquarters of the Institution at 8, Gokhale Road, Kolkata 700 020, expressing his desire to appear in a particular examination together with the requisite fee (**Appendix V**) by Bank Draft within the period (Ref. 3.2) of receipt of such forms as may be notified from time to time.

- 3.2 Applications shall be received at the headquarters of the Institution on working days normally within the period as per the following schedule:

Candidates not appeared at immediately preceding examination

February 15- March 15 (for Summer Term)

August 17- September 15 (for Winter Term)

Candidates appeared at immediately preceding examination

March 16- April 14 (for Summer Term)

September 16- October 15 (for Winter Term)

- 3.3 The Institution reserves the right to reject any application, which is not properly filled-in, does not accompany the prescribed fee, is not received within the stipulated date or for any other reason. The decision of the Institution in this respect shall be binding upon the applicant.
- 3.4 Examination fee once paid are neither refundable nor transferable to a subsequent examination or to any other account except in case of rejection of an application. In such case of rejection of an application, the fee paid will be refunded after deduction of the processing fee (**Appendix VIII**).

4. IDENTITY CARD

- 4.1 Each Technician/ Senior Technician member of the Institution shall be required to produce an Identity Card, issued by the headquarters of the Institution, to appear at examinations. Associates/ Corporate members shall be required to apply to the Institution for issue of the Identity Card and they are required to produce the same to appear at examinations. The Identity Card shall indicate name of the member, class/ grade of membership with number, postal address, photograph and specimen signature of the member duly attested by a Corporate Member of the Institution.
- 4.2 **No candidate shall be allowed to appear at an Examination without production of his valid Identity Card issued by the headquarters of the Institution.**
- 4.3 In case of lost/ defective Identity Card, the concerned member is required to apply to the headquarters of

the Institution for a DUPLICATE IDENTITY CARD, along with prescribed fee.

- 4.4 To effect any correction/ alteration, a member is required to apply to the Institution for fresh Identity Card along with prescribed fee (**Appendix VI**) and to surrender his existing Identity Card. On surrender of such Identity Card, a fresh Identity Card shall be issued to the member.

5. ADMIT CARD

- 5.1 Candidates are required to download the Admit Card from the web portal www.ieindia.org, 7 days prior to the commencement of examination.
- 5.2 A candidate shall be required to produce his Admit Card at the Examination Centre.
- 5.3 Centrewise index showing *inter alia* the membership class, number and corresponding roll number shall be available at respective (i) Examination Centre opted by the candidate, and (ii) at State/ Local Centre, to which he is attached, for information of the applicant whose application will be in order in all respects.
- 5.4 If a candidate claims that in spite of submitting an application in conformity with Rules, he has neither been provided with Admit Card nor with any information about rejection of his application, he can submit a fresh application personally to the Officer-in-Charge along with a Special Fee (**Appendix VIII**) payable to the Institution.

In such a case, permission to appear in the examination may provisionally be accorded subject to the condition that the candidate submits documentary evidence in support of his claim and that he is otherwise eligible to appear in the subject(s) in accordance with the Rules. In case the candidate's claim is found to be not in order by the Headquarters of the Institution at any point of time, the fee deposited by him shall be forfeited and his appearance shall be treated as irregular.

6. CENTRES FOR EXAMINATION

- 6.1 The examinations of the Institution are being held at the cities/ towns as given in **Appendix VII**. However, the Council of the Institution reserves the right to establish or abolish one or more Examination Centres without assigning any reason whatsoever.
- 6.2 Every endeavour will be made to normally allow an

applicant to appear from an Examination Centre opted by the candidate if the same is located within the jurisdiction of his State/ Local Centre. However, the Institution reserves the right to allot a Centre, different from the Centre opted by the candidate, without assigning any reason whatsoever.

- 6.3 Request for a change of Examination Centre may not be entertained.

7. MEDIUM OF EXAMINATIONS AND UNITS

- 7.1 English is the medium of examinations. However, Senior Technician member, appearing Section A and Section B Examinations, on prior application, may be permitted to write his answers in **all subjects** in Hindi, provided he has passed the Diploma Examination in engineering in Hindi medium.
- 7.2 A candidate, once permitted to use a regional language or Hindi, shall not be permitted to use any other language in any subject subsequently.
- 7.3 SI units, standard symbols and notation are recommended for the examinations.

8. RESULTS OF EXAMINATIONS

- 8.1 The results of an examination shall normally be published within **fourteen** weeks after the completion of the examination. List of qualifying candidates and list of subject(s), in which the candidates secured grade 'C' or higher grade, shall be available at the office of State/ Local Centre of the Institution, under which the Examination Centre is located, for information of the candidates. The information may also be available at the Institution's Website.
- 8.2 No application from a candidate for re-valuation shall be entertained under any circumstance, whatsoever.
- 8.3 Scrutiny of all answerscripts as to whether all answers in the answerscripts were valued, marks allotted in answerscripts were added correctly and marks were transferred and added correctly shall be undertaken before finalisation of results.
- 8.4 Any complaint arising out of matters, other than those mentioned in Clause 8.2 above, may be considered if lodged within 60 days after declaration of results.
- 8.5 The Council reserves the right to withhold or cancel the result of any candidate at any examination in which case the grade card will not be supplied.
- 8.6 Appearance of a candidate at an examination without being allotted a roll number shall lead to cancellation of all subjects in which he appeared in that particular examination.

- 8.7 A candidate shall be required to pass the examination within a specific period as mentioned hereunder:

Section A : 6 (six) years from the date of election for Technician/ Senior Technician member.

Section B : 6 (six) years from next term of passing Section A Examination.

No further extension shall be permitted beyond the stipulated period.

After expiry of six years period of Section A/ Section B examination, a candidate will be required to apply for re-registration of another six years to appear afresh in all applicable number of subjects of Section A/ Section B examination. Re-registration period shall be counted from the immediate next term of expiry of six year period.

The above stipulated period for Section B is also applicable to Senior Technicians/ corporate members exempted to appear in Section A Examination from the date of their election as Senior Technician member or first appearance as corporate member as applicable.

Corporate members, desiring to appear in additional branch, are required to register for Section B (Ref. 2.3).

In case the candidate desires to change the additional branch of engineering, he shall be required to apply afresh (Ref. 2.3). However, for such candidates, 6-year period shall be counted from the date of his first appearance in the old additional branch.

- 8.8 Candidates appear in a particular session in Section A/ Section B examination may appeal for verification of answerscript(s) for arithmetic correction in totaling of marks and any omission/ deletion in evaluation within 15 days from the date of declaration of results at HQs of the Institution on the prescribed proforma with requisite fee (**Appendix VIII**). On receipt of the request from the candidate with fee, the exact date and time will be informed to him to inspect his/ her answerscript at the HQs of the Institution at his own expense. In case any candidate fails to appear to inspect his answerscript(s) at the given date and time, no further opportunity shall be given for inspection of answerscript(s). It is further clarified that re-verification of answerscript shall not tantamount to re-valuation of answerscript. This is only a process of re-verification by the candidate. The relation period of such answersheets will be six months.

9. DISCIPLINARY ACTION

- 9.1 All cases of unfair means and irregularities reported to or detected by the Institution shall be investigated with intimation to the concerned candidate.
- 9.2 Pending finalisation of any case, the result of the concerned candidate shall be withheld and he shall not be eligible to appear in subsequent examinations.
- 9.3 The decision of the Institution shall be communicated to concerned candidate and shall be final and binding on him.
- 9.4 The District Court at Alipore, 24 Parganas (South), West Bengal, shall have the exclusive jurisdiction in matters arising out of conduct of Institution Examinations and/ or penal measures or any decision of the Council of the Institution giving or imposing penalty to any candidate.

10. CERTIFICATES

- 10.1 Provisional Certificate shall be issued on passing Section B examination to the candidate along with the grade card of Section B examination.
- 10.2 A Pass Certificate shall be issued to a candidate on his passing Section B examination. A duplicate certificate shall be issued on payment of requisite fee (**Appendix VI**) provided a candidate gives an undertaking that the original has been lost, and enclose a FIR/ General Diary/ affidavit to this effect from the competent authority.
- 10.3 Pass Certificates of any year shall be awarded to eligible candidates, at the Convocation to be held in the following year, on receipt of their written consent to attend the Convocation with valid Identity Card and grade card/ provisional certificate issued by the Institution for verification.

After the Convocation, Pass Certificates shall be sent to the candidates by registered post, who will not be able to attend the Convocation.
- 10.4 If any candidate uses a language other than English in an examination under the provision of Rules 7.1 and 7.2, mention of the language shall be made in the certificate.
- 10.5 Candidates passing only Section B Examination in any branch will also be issued a certificate to that effect.

11. GRADE CARDS

- 11.1 The grade cards for Sections A and B complete pass candidates in an examination shall be sent by registered post. However, grade cards of unsuccessful candidates shall be sent by ordinary post.

- (i) In case of non-receipt of grade card by a candidate, who passed Section A or Section B Examination, within six weeks after declaration of results, a duplicate grade card shall be issued on submission of application in the prescribed format with requisite fee only when a candidate gives an undertaking that the original grade card has been lost, and enclose a FIR/ General Diary/ Affidavit to this effect from the competent authority.
- (ii) In case of unsuccessful candidates in Section A or Section B, the requirement of a FIR/ General Diary/ Affidavit is not applicable.

12. PROJECT WORK

- 12.1 A candidate shall be eligible for project work only after securing minimum grade 'C' in 5 (five) subjects in an engineering branch of Section B. Grade card along with prescribed format for project work and laboratory experiments and guidelines shall be sent to all such candidates. The prescribed format shall be returned duly filled-in by the candidates within the stipulated period.
- 12.2 On receipt of the application, a candidate shall be intimated the name and address of the project guide, who in turn shall assign the project work to the candidate.
- 12.3 Full marks for the project work will be 100 (one hundred). There will be internal as well as external evaluation of the project work. Minimum aggregate for passing project work will be grade 'B'. The internal evaluation will be carried out by the project guide based on the project report submitted by the candidate to him. One copy of the project report will be submitted by the candidate to the project guide and another copy to the Headquarters of the Institution. External evaluation will be done by the Institution. In case a candidate fails to pass the project work in one or more attempts, he shall be required to re-register again for the same with the prescribed fee. Project work shall be required to be completed within the stipulated period of 6 (six) years (Ref : Rule 8.7).
- 12.4 In case of death of the project guide or his change of address affecting the facility of contact between him and the candidate, the candidate shall inform to the Chairman of his State/ Local Centre for an alternate project guide.
- 12.5 A candidate shall be required to maintain a diary and to prepare a self-assessment report in the prescribed format pertaining to the work undertaken by him as assigned by the project guide.

12.6 For change of branch of engineering or optional subject(s), a candidate shall be required to apply afresh in stipulated time period, as mentioned in Rule 2.3. The time period shall not be extended for any reason whatsoever.

13. LABORATORY EXPERIMENTS

13.1 A candidate shall be eligible for laboratory experiments only after securing minimum grade 'C' in 5 (five) subjects in an engineering branch of Section B. Grade cards along with prescribed format for project work and laboratory experiments and guidelines shall be sent to all such candidates. The prescribed format shall be returned duly filled-in by the candidates within the stipulated period.

13.2 On receipt of the application, a candidate shall be intimated the name of the university/ engineering

college/ institute, where a candidate shall be required to perform the laboratory experiments. Fee for laboratory experiments are required to be paid by the candidate as specified in the guidelines.

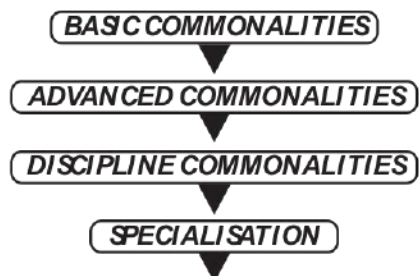
13.3 Full marks for the laboratory experiments will be 100 (one hundred). The evaluation of the same shall be carried out by the concerned university/ college/ institute where the candidate shall perform the laboratory experiments. Minimum grade for passing laboratory experiments will be grade 'B'. In case a candidate is not able to complete required number of laboratory experiments and obtain grade 'B', he shall be required to re-register again for the same with the prescribed fee. Laboratory experiments are required to be completed within the stipulated period of 6 (six) years (Ref : Rule 8.7).

DEVELOPMENT OF COURSE STRUCTURE

The generalized commonalities of the programme, which are prerequisite for developing scientific mind and engineering attitude, is first identified and classified as *Basic Commonalities*

A global outline for developing professional expertise around a common theme is identified next. This is classified as *Advanced Commonality*.

A discipline wise commonalities are developed next, followed by specialisation in each discipline.



BASIC COMMONALITIES

To develop the basic commonalities, it is essential to first identify the fields of activities. A student of engineering is required to have:

- Adequate knowledge of basic sciences;
- Adequate knowledge and application of engineering sciences;
- Appreciation of environment and society on engineering activities; and
- Adequate communication skill to communicate with engineering process, people and machine.

The subjects to cover the above fields are broadly as below :

Basic Sciences

Physics, Chemistry and Mathematics.

Engineering Sciences

Fundamentals of Design and Manufacturing, Electrical Science, Electronics & Instrumentation, Mechanical Science, and Material Science and Engineering.

Social Science

Societal structures and dynamics, development processes, technology assessment, ecosystems, environmental degradation, waste management and sustainable development.

Communication

Engineering Drawing and Graphics, Computing and Informatics.

A course structure, identified as **Section A**, common for all disciplines, based on the above considerations, has been evolved.

ADVANCED COMMONALITIES

The course structure for each discipline in **Section B** have one common subject **Engineering Management**, except Marine Engineering discipline.

DISCIPLINE COMMONALITIES AND SPECIALISATION

The various task groups of each discipline developed the course structure for each, keeping the discipline commonalities confined to five papers and specialisation to three papers from one of the optional groups.

The course structure and syllabi of 15 engineering disciplines have been divided into two parts—engineering disciplines in which **Section B** examination are being conducted at present, followed by engineering disciplines in which **Section B** examination are not being conducted.

Codes for the Schemes, Branches and Subjects

SECTION A EXAMINATION

Diploma Stream

(Scheme Code 3)

AD 301 Fundamentals of Design and Manufacturing

AD 302 Material Science and Engineering

AD 303 Computing and Informatics

AD 304 Society and Environment

SECTION B EXAMINATION

(Scheme Code 4)

CHEMICAL ENGINEERING

(Branch Code 04)

(See page 19 for subject codes)

CIVIL ENGINEERING

(Branch Code 05)

(See page 27 for subject codes)

COMPUTER SCIENCE AND ENGINEERING

(Branch Code 06)

(See page 38 for subject codes)

ELECTRICAL ENGINEERING

(Branch Code 07)

(See page 47 for subject codes)

ELECTRONICS AND COMMUNICATION ENGINEERING

(Branch Code 08)

(See page 57 for subject codes)

MECHANICAL ENGINEERING

(Branch Code 11)

(See page 67 for subject codes)

MATERIALS AND METALLURGICAL ENGINEERING

(Branch Code 12)

(See page 78 for subject codes)

MINING ENGINEERING

(Branch Code 13)

(See page 86 for subject codes)

PRODUCTION ENGINEERING

(Branch Code 14)

(See page 94 for subject codes)

TEXTILE ENGINEERING

(Branch Code 15)

(See page 101 for subject codes)

AEROSPACE ENGINEERING

(Branch Code 01)

(See page 111 for subject codes)

AGRICULTURAL ENGINEERING

(Branch Code 02)

(See page 121 for subject codes)

ARCHITECTURAL ENGINEERING

(Branch Code 03)

(See page 132 for subject codes)

ENVIRONMENTAL ENGINEERING

(Branch Code 09)

(See page 141 for subject codes)

MARINE ENGINEERING

(Branch Code 10)

(See page 150 for subject codes)

ENGINEERING

Evolution of the Engineer

Historical records reveal that Darius I, King of Persia (521-485 BC), employed Mandrocles of Samos to bridge the Bosphorus with boats so that his army might march against the Scythians. Alexander's army included surveyors like Baeton, Diognetus, Philonides and Callisthenes. Archimedes (287-212 BC) acted as military adviser to King Hiero.

During the medieval period, Leonardo da Vinci (1452-1519) was Military Engineer to the Duke of Milan for 18 years and Galileo (1564-1643) was the Professor of Physics and Military Engineering. It may be surmised that 'engineer' (ingenium) was the title in Italy for those who carried out military activities like building war machines and fortifications.

The word 'engineer' may well have originated from the fact that these people developed the technical aids of warfare and defence which were then known as 'ingenia'. However, in Italy, surveyors and canal builders were also called 'ingeniarii'. Towards the end of the 17th Century, the term 'ingenieur' had been suggested as a professional title for scientifically trained technicians.

But perhaps the most apt and general conception of an engineer has been given by H R Palmer in 1818 when he says that an engineer is a mediator between the



ENGINEERS' DAY

September 15 is a day of profound significance in the annals of Indian engineering, for on that day, over a century ago, was born the Engineering Wizard, Bharat Ratna, Sir Mokshagundam Visvesvaraya, who fought many a life's battle through a wisdom and action to serve the country for a creative tomorrow, won them all and lived as long, and more, as a man can hope to live, a life rich in fruits and ending surrounded by honour and love. His masterful expositions and achievements in the fields he covered are monumental, verily outreaching national frontiers. Any attempt to delineate his towering personality in its variegated aspects can only be too unequal, however well begun, to reach totality. Nevertheless, the celebrations on this day, rightly called the Engineers' Day, as laid down by the Council of the Institution, to be observed every year is a modest demonstration of the 'nation', specially the engineers, of the sense of gratitude and reverential esteem in which they hold Sir M. V.

philosopher and the working mechanic, and like an interpreter between two foreigners, he must understand the language of both. Hence, there is the absolute necessity of his possessing both practical and theoretical knowledge.

The Beginning of Engineering

Historically, engineering was classified primarily into two groups: military engineering and civil engineering. With the unidirectional flow of time, applications of civil engineering became gradually complex, the civil engineering discipline showed a tendency of dividing into branches of specialization. For instance, civil engineering came to be

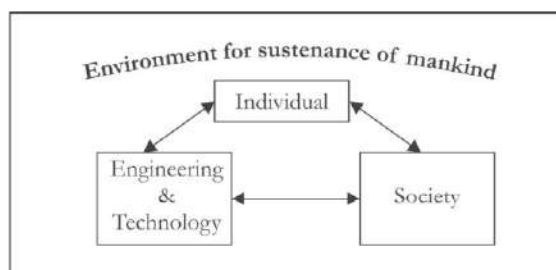
concerned primarily with static structures like dams, bridges and buildings, whereas the new budding branch mechanical engineering concentrated on the dynamic structures such as machinery and engines. In the same manner, mining engineering fortified itself in the excavation of ore bodies from geological structures and related mining machineries, whereas metallurgical engineering went a step further to extract and refine the ores with advancing technologies. Electrical and Chemical engineering applied themselves to the safe and sound practical applications of electricity and chemistry, respectively.

Concept of Engineering

Engineering is the art of utilizing the great sources of power in nature for the benefit, convenience and survival of mankind. In its modern form, engineering involves men, money, materials, machines and energy. It is differentiated from science in that it is primarily concerned with how to direct the discoveries of pure science to useful and economical ends and formulate acceptable theories and practices from them. Engineering,

therefore, demands the creative imagination and originality to innovate useful applications of natural phenomena.

It continuously seeks newer and novel, cheaper and better means of using unfathomable riches of natural sources of energy and materials.



Differentiation in Engineering

As a consequence of deep penetrating specialization, a broad discipline gave birth to several distinct disciplines in line with the process of differentiation. Thus, for example, civil engineers, by virtue of specialized training, could become water-power engineers or construction engineers; just as mechanical engineers could be machine-design engineers or industrial engineers; electrical engineers as power or communication engineers. Examples exist for other such commonly known disciplines as well.

Technology — The Other Face

Technology, on the other hand, is a tool-in-aid to engineering. The aim of technology is to reduce 'work', specially at a juncture when the content and nature of work is changing at an overwhelming pace. More and more often a person works as part of a 'man-machine' system, his work gets enhanced due to the necessity of handling more and more information. The change in the nature of work affects deeply both the individual and the society. This change is generally welcome as it reflects the dynamism inherent in a lively society, for 'work' constitutes the most important functional interdependence between the individual and the society. This dependence brings into focus the prevailing values and legal basis of society. This calls for redefining and enlarging the concept of work to include, in addition to traditional paid work, all other useful activities.



Qutab Minar

Imprints of Technology

As a result of this ever-increasing utilization of technology, mankind and his environment have been affected both favourably and adversely only because the society has been unable to adapt to the changes in the nature of work brought about by rapid development of technology. The increasing complexity of specialized machines and automated processes have invited physical and psychological problems for the operating personnel. This has led to the development of bio-engineering and ergonomics, concerned with the physical effects upon man, and management engineering concerned with the effects on his psyche.

Rebuilding by Integrative way

Along with specialization, integrative influences have also taken place in the engineering field through interdisciplinary activity. The growing complexity of modern technology has rendered the co-operation of many specialists essential in the design of industrial processes and machines. For instance, design of a modern structure involves dealing with not only the static structural members but also of moving parts like elevators; electrical machinery and power distribution as well as communication systems; heating, ventilating and air conditioning; fire protection; dynamic response of the structure to wind and earthquake are also to be studied. Above all, ecological considerations are now gaining importance. Because men and money are as much involved in engineering as materials, machines, and energy sources, the management engineer has come to exist as another co-ordinating and integrating factor.

Shaping an Engineer

A typical modern engineer must go through several phase of career building activity. His formal education needs to be broad-based and deep in the sciences and humanities. He is then exposed to an increasing degree of specialization in the intricacies of his particular discipline, and has to keep himself up to date through continuing education. As he progresses, he is required to gain interdisciplinary knowledge for effectively supervising a variety of specialists. Finally, the engineer is entrusted with the management functions of interweaving men, money, materials, machines and energy sources to generate an integrated fruitful process directed to raising the standard of living of the society.

SECTION A (Non-Diploma Stream)

AN 201

FUNDAMENTALS OF DESIGN AND MANUFACTURING

Group A

Engineering design process and its structure. Identification and analysis of need, product design specifications, standards of performance and constraints.

Searching for design concepts; morphological analysis, brainstorming. Evaluation of design concepts for physical reliability, economic feasibility and utility.

Detailed design; design for manufacture, assembly, shipping, maintenance, use, and recyclability.

Design checks for clarity, simplicity, modularity and safety. Standardization and size ranges. Reliability and robust design. Design organisation and communication, technical reports, drawings, presentations and models.

Concept of manufacturing; classification of manufacturing processes. Fundamentals of casting. Basic understanding of commonly used casting processes (sand casting, investment casting and permanent mould casting processes).

Fundamentals of metal forming; hot and cold working; basic understanding of primary metal forming processes (rolling, forging, extrusion and drawing processes, punching and blanking).

Group B

Fundamentals of metal cutting; tool-work interaction for production of machined surfaces. Classification of machining processes. Basic machining operations (turning, shaping, planning, drilling and milling processes).

Fundamentals of grinding and finishing; overview of unconventional machining processes; fundamentals of welding processes; introduction to primary welding and allied processes; selection of manufacturing processes. Design for manufacturability.

Need for integration—commercial, economic and technological perspective; basic tools of integration; concept of a system. Introduction to information technology and its elements.

Introduction to group technology; introduction to simulation and database management systems.

Elements of integration—controllers, sensors, robots, automated machines, AGVs, AS, RS, etc.

Product and process design for integration; design for economic manufacturing; design for manufacturing integration.

Introduction to computer aided process planning; selection of machine tools.

Recommended Books

- ◆ G K Lal, Vijay Gupta and N Venkat Reddy. Fundamentals of Design and Manufacturing. Narosa Publishing House, New Delhi.
- ◆ Surendra Kumar and M K Tiwari. Fundamentals of Design and Manufacturing. IET Study Material.

Reference Books

- ◆ G Dieter. Engineering Design. McGraw-Hill International.
- ◆ G K Lal and SK Choudhary. Fundamentals of Manufacturing Processes. Narosa Publishing House, New Delhi.
- ◆ SK Vajpayee. Principles of Computer Integrated Manufacturing. Prentice-Hall of India (P) Ltd., New Delhi.

AN 202

MATERIAL SCIENCE AND ENGINEERING

Group A

Introduction to materials. Metal and alloys, ceramics, polymers and semiconducting materials—introduction and application as engineering materials.

Defects in solids. Point, line and surface defects. Diffusion in solids.

Phase diagrams. Monocomponent and binary systems, non-equilibrium system, phase diagram and application in crystalline and non-crystalline solids.

Mechanical properties. Tensile strength, yield strength, elastic and viscoelastic properties, creep, stress relaxation and impact. Fracture behaviour. Ductile fracture, Griffith theory, effect of heat treatment and temperature on properties of metals.

Deformation of metals. Elastic and plastic deformation, slip, twin, dislocation theory, critical resolved shear stress, deformation in polycrystalline materials, strain cracking, Bacher's effect, strengthening mechanisms, work hardening, recovery, crystallisation and grain growth, cold and hot working.

Group B

Heat treatment. Iron-carbon system. Annealing, normalising, hardening, critical cooling rate, hardenability, age hardening, surface hardening, tempering.

Thermal properties. High temperature materials, materials for cryogenic application, thermally insulating materials. (Specific heat, thermal conductivity, thermal expansion).

Ceramic materials and polymers. Silicon structures, polymerism fraction in glass, electrical properties of ceramic phases, rocks, building stones, refractories.

Polymerisation mechanism, structural properties of polymer, thermoplastics, thermosets, elastomer, resins, composites, particle and fibre reinforced composite. Composite material including nano material.

Electronic properties. Magnetism, diamagnetism, paramagnetism, ferromagnetism, magnetic energy, zone theory of solids, zones in conductors and insulators.

Recommended Books

- ◆ M. Poonia. *Materials Science and Engineering*. Khanna Book Publishing, Delhi
- ◆ L. A. Vanblask. *Elements of Material Science and Engineering*. Addison-Wesley (Indian edition).
- ◆ V. Raghavan. *Material Science and Engineering*. Prentice-Hall of India (P) Ltd., New Delhi.

AN 203

COMPUTING AND INFORMATICS

Group A

Programming languages. C including C++; Languages—declarations, expressions, control statements, arrays, functions, pointers and structures; Algorithms and flow-charts. Introduction to Pascal.

Informatics. Information systems for decision making; Data management and database management technology; Office automation system—LAN, WAN, electronic mail, electronic data interchange; client server technology; overview of TCP/IP; Information systems for business; Strategic information systems; Information resources management.

Group B

Computer basics. History, generations and classification of computers; Number systems; Boolean algebra.

Hardware. Introduction to logic gates and flip flops; components of a computer input/output devices, CPU unit and memory unit, secondary storage.

Software. System software; application software; compilers and translators.

Operating systems. Introduction to operating systems; types of operating systems and their functions; popular operating systems—MS-DOS, UNIX and Windows; file management.

Recommended Books

- P. B. Mahapatra. *Computing and Information*. IET Study Material.
- D. K. Basu, et al. *Computer Systems and Data Analysis*. Narosa Publishing House, New Delhi.
- N. S. Gill. *Handbook of Computers Fundamentals*. Khanna Book Publishing Co. Ltd., New Delhi.
- P. B. Mahapatra. *Thinking in C++*. Khanna Publishing, New Delhi.

AN 204

SOCIETY AND ENVIRONMENT

Group A

Society

Societal Structures and Dynamics

An analysis of basic sociological concepts and their applications to contemporary society; social stratification, caste, class, cultural heritage, occupation, mobility and income distribution. Social tensions and their causes; societal responsibilities and social institutions.

Development Processes

Parameters for development. Interrelationship between social, economic and scientific factors. Role of science and technology in development. Planning—its objectives and assessment.

Technology Assessment

Historical development of science and technology. Criteria for assessment of appropriate technology and technology adaptation.

Group B

Environment

Ecosystems

Natural ecosystems. Principles of ecobalance. Biosphere cycle, carbon dioxide cycle. Causes for eco-imbalance—its effects and remedies.

Environmental Degradation

Causes for degradation—its effects. Control of air, water, soil and noise pollutions. Protection of ozone layer.

Waste Management

Agricultural, urban and industrial wastes.

Sustainable Development

Definition and concept. Technology for sustainable energy and materials.

Recommended Books

- S. C. Sharma and M. P. Poonia, *Environmental Studies*. Khanna Book Publishing Co. (P) Ltd., New Delhi.
- I. Ghosh. *Society and Environment*. IET Study Material.
- R. Sharan, et al. *Engineering, Environment & Society*. The Institution of Engineers (India), Kolkata

AN 205

MECHANICAL SCIENCE

Group A

Mechanics of Solids

Coplanar force systems, moment of a force, couple, equilibrium conditions, free-body diagram, laws of friction.

Centroid and area moment of inertia, mass moment of inertia, principle of virtual work, screw jack.

Kinematics of particles, velocity, acceleration, Newton's laws, equation of motion (rectilinear), momentum, impulse, work/energy, projectiles, moment of momentum, rotation and simple harmonic motion, free vibration.

Mechanics of Deformation

Stress, strain, Hooke's law, elastic constants, ultimate strength, Mohr's circle of stress, thin-walled pressure vessels.

Deflection of beam—bending moment and shear force in beam/ cantilevers, torsion of circular sections.

Group B

Fluid Mechanics

Fluids and their properties, viscosity, compressibility, surface tension, non-Newtonian fluids, pressure at a point, hydrostatic forces on immersed and floating bodies, type of flow, velocity and acceleration of a flow particle, hydrodynamics.

Thermodynamics

Basic concepts—properties of gases and equation of state, work, heat, heat capacity, internal energy, enthalpy.

First law of thermodynamics and law of conservation of energy, basic thermodynamic processes for ideal gases.

Second law of thermodynamics, Carnot cycle, entropy, various processes on T-s and H-s planes.

Ideal heat engine cycles—SI and CI engine cycles, principle of operation of SI and CI engines.

Recommended Book

- G K Lal, Vijay Gupta, N G R Iyengar, B N Banerjee and K Ramesh. Mechanical Science. Narosa Publishing House, New Delhi.

Reference Books

- PK Nag. Engineering Thermodynamics. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- SH Crandell, N C Dahl and T J Lardner. An Introduction to the Mechanics of Solids. McGraw-Hill International.
- D S Bedi, Strength of Materials (Sixth Edition) Khanna Publishing, New Delhi.

AN 206

ENGINEERING PHYSICS AND CHEMISTRY

Group A

Engineering Physics

Atomic structure, Rutherford and Bohr's models, atomic process. Proton and neutron, radioactivity and decays. Nuclear energy and reactions, nuclear reactor. Introduction to quantum physics.

Inter-atomic forces in solids, anisotropic properties. Distinction between metal and semi-metals. Semiconductor, insulator and superconductor. Dielectric materials. Types of dielectric polarisation. Piezo, pyro and ferroelectric materials and their electrical and optical properties.

Kinetic theory of gases. Temperature and kinetic energy, ideal gas laws. Principle of statistical mechanics. Boltzmann's law, Brownian movement, equipartition of energy and thermal equilibrium of radiation.

Optics. Interference, diffraction and polarisation, laser, holography, fibre optics.

Crystalline and amorphous material, crystal geometry, crystal directions and planes. Space lattices. Crystal symmetry and structure. Crystal bonding. Interatomic forces in solids. Anisotropic properties.

Group B

Engineering Chemistry

Chemical bond. Ionic and covalent bonding; Lattice energy; Hybridisation; Resonance; Bond order; Fajan's rule; Metallic bond and intermolecular forces; Chemical kinetics.

Structure of organic molecules, nomenclature. Introduction to stereochemistry; Optical activity. Titration involving potassium permanganate, potassium dichromate. Titration involving EDTA.

Oxidation-reduction reactions. Colloid and surface chemistry; Corrosion; chromatography and ion-exchange catalysis; Crystal structure and electro-chemistry; UV visible spectrophotometry. Chemical kinetics—simple reactions.

Environmental chemistry. Pollutant analysis, eg, CO, H₂, S, NO_x, SO_x, oxidant.

Recommended Books

Engineering Physics

- David Halliday, R Resnick and K S Krane. Physics (Vols I & II). John Wiley and Sons, International edition, Singapore.
- V Raghavan. Material Science and Engineering. Prentice-Hall of India (P) Ltd., New Delhi.

Engineering Chemistry

- J E Huheey. Inorganic Chemistry. Harper and Row Publishing, Singapore.
- PW Atkins. The Elements of Physical Chemistry. Oxford, New York.
- R T Morrison and R M Boyd. Organic Chemistry. Allyn-Bacon Publishing, Boston.
- G H Jeffery, et al. Vogel's Textbook of Quantitative Chemical Analysis, ELBS, Longman.
- Satyaprakash, Environmental Chemistry. Khanna Publishing, New Delhi.

Group A

Projection graphics. Objects, condition and methods of projection; Gnomonic, stereographic and orthographic projections; Coordinate systems and grid scales, scale distortion, and conditions of conformality and equivalence. Axonometric projections; Isometric; Dimetric and oblique projections; Conical equivalent and equivalent cylindrical projections.

Spatial graphics. Basic principles of multiview drawings and Monge's projections; Points in quadrants and octants; Projections of lines and traces of lines; True relative positions of two planes and of a straight line and a plane; Method of revolution. Projections of polyhedrons, curved lines and surfaces; Contour mapping of curved surfaces; Plane sections of polyhedrons and curved surfaces; Intersection of planes and surfaces and lines and surfaces; Development of curved surfaces. Affine correspondence and its applications.

Product graphics. Introduction to various product features; identification of functional and non-functional surfaces; Selection of datum; Tolerancing of dimensions; Compatibility of product elements for manufacturing and assembly requirements; Sectional and auxiliary views.

Computer graphics. Basic principles for interactive computer graphics; Systems and peripherals required; Point plotting technique; Line drawing displays; Modelling of two- and three-dimensions; Display of solid objects.

Group B

Drafting principles. Manipulation and use of drafting equipment and instruments; Exercises in instrumental drawing; Introduction to drafting codes as per ISO and BIS; Technical lettering.

Drawing exercise. Drafting problems involving consideration of stereometric features; Toleranced dimensioning; partial views and sectioning, auxiliary sections, schematic product symbols. Drafting exercises involving (a) preparation of details, (b) aggregation for assembly, (c) exploded machine kinematics, etc.

Recommended Books

- K Venugopal, Engineering Drawing and Graphics. New Age International (P) Ltd, New Delhi.
- P S Gill. Engineering Drawing. SK Kataria & Sons, Delhi.
- W J Luzaddor. Fundamental of Engineering and Drawing. Prentice Hall Inc., New York.
- T E French, C J Vierek and R J Foster. Graphics Science and Design. McGraw-Hill, New York.
- N D Bhatt. Engineering Drawing and Graphics. Charotar Publishing House, Anand (Gujarat).

Group A**Electronics**

Semiconductor materials, intrinsic and extrinsic semiconductors.

p-n junction diodes, rectifiers—half wave, full wave, capacitive filters, Zener diodes, their operation, characteristics and applications.

Transistors—p-n-p and n-p-n transistors, transistor as amplifier—CE, transistor characteristics, biasing and biasing stability, small signal equivalent circuits. Field effect devices—MOSFET—characteristics and applications. BJT—characteristics.

Amplifiers—Hybrid parameter equivalent circuits for common emitter configuration, current and voltage gain, input-output impedance, frequency response, concepts of feedback amplifiers, regenerative feedback and conditions for oscillation.

Thyristors—characteristics and applications. Triacs and GTOs.

Integrated circuits—IC devices. OPAMP applications. Analogue to Digital Conversion (ADC), Digital to Analogue Conversion (DAC).

Group B**Instrumentation**

Indicating instruments. Moving coil, moving iron, rectifier and dynamometer type meters for measurement of voltage, current, resistance and power. Integrating meters.

Electronic voltmeters—peak, r.m.s. and average reading type voltmeters. CRO—functional block diagram, operation and application.

Electronic instruments. Q-meters, distortion meters, spectrum analyzers, audio oscillators and RF signal generators, introduction to digital voltmeters, digital display devices.

Sensors and transducers. Resistive, inductive and capacitive pick ups for non-electrical quantities. Analogue and digital data acquisition and transmission systems.

Recommended Books

- A M Shed. Electronic Devices and Circuits. Prentice-Hall of India (P) Ltd., New Delhi.
- AK Maini. All-in-One Electronic Simplified. Khanna Book Publishing Co. (P) Ltd., New Delhi.
- Rishabh Anand, Digital Electronics and Intelligent Instrumentation for Engineers, Khanna Publishing
- A D Helfrick and W D Cooper. Modern Electronic Instrumentation and Measuring Techniques. Prentice-Hall of India (P) Ltd., New Delhi.

ENGINEERING MATHEMATICS

Group A

Calculus of Functions of Variables

Calculus of functions of one variable Successive differentiation, Leibnitz's theorem, Rolle's and Mean value theorems. Taylor's and Maclaurin's expansion theorems. Fundamental theorem of integral calculus. Elementary reduction formulae for integrals. Applications to length, area, volume, surface area of revolution, moments of centre of gravity. Infinite series—convergence, divergence ratio tests, etc.

Calculus of functions of several variables: Partial derivatives, gradient and directional derivatives. Differentiation of implicit functions, exact differentials, tangents, normals, maxima, minima, saddle points. Method of Lagrange's multiplier. Multiple integrals.

Vector Calculus

Scalar and vector fields. Line and surface integrals. Gradient and divergence. Green's and Stoke's theorems and their applications.

Linear Algebra

Vector spaces—linear independence and dependence of vectors, inner products, linear transformations. Matrices and determinants. Systems of linear equations—consistency and inconsistency. Gauss elimination, rank of a matrix, inverse of a matrix. Eigen values and eigenvectors of a matrix, diagonalization of a matrix.

Group B

Ordinary Differential Equations (ODEs)

Formation of ODEs, definition of order, degree and solutions. ODEs of first order; separable variables, homogeneous and non-homogeneous equations, exactness and integrating factors, linear equations and Bernoulli's equations (general linear ODEs of n th order, solutions of homogeneous and non-homogeneous equations, operator method, methods of undetermined coefficients and variation of parameters). Solutions of simple simultaneous ODEs. Partial differential equations and its applications. Transforms theory—Laplace, Fourier, etc.

Numerical Methods

Difference operators—forward, backward, central, shift and average operators, and relations between them. Newton's forward and backward interpolations. Lagrange's interpolation and the error formula for interpolation. Numerical differentiation and integration—Trapezoidal rule and Simpson's one-third rule, including error formulae.

Introduction to Probability and Statistics

Basic concepts, including introduction to probability theory, Venn diagrams, central limit theorem, mean, mode and median. Properties of Beta, Poisson, Exponential and Normal distributions. Correlation and regression, Student's t -distribution

test, Chi-square and F tests of significance.

Recommended Books

- E Kreyszig. Advanced Engineering Mathematics. New Age International Ltd., New Delhi.
- RS Salaria, Computer Oriented Numerical Methods Khanna Book Publishing Company (P) Ltd., New Delhi.
- G B Thomas and R L Finney. Calculus and Analytic Geometry. Narosa Publishing House, New Delhi.
- Reena Garg, Engineering Mathematics Khanna Book Publishing Co. (P) Ltd, New Delhi.

ELECTRICAL SCIENCE

Group A

Review of basic concepts in electrostatics and magnetostatics. Basic laws due to Ohm, Coulomb, Faraday, Ampere and Kirchhoff. Network parameters and theorems. Superposition theorem. Thevenin and Norton's theorems. Network analysis. Steady state response of circuits to sinusoidal functions. Power and power factor. Phasor representation of sinusoidal complex impedances. Resonance. Magnetic field calculations. Magnetization curves. Magnetic circuit concepts and calculations. Hysteresis and eddy current losses. Relays.

Polyphase circuits—Three-phase supply systems. Phase sequence. Balanced three-phase circuits. Star and delta connected loads. Unbalanced three-phase circuits. Symmetrical components. Power measurement in three-phase circuits. Active and reactive power. Power factor improvement.

Group B

Elements of power distribution—d.c. 2-wire, 3-wire distribution. a.c. 3-wire and 4-wire distributions. Radial and ring main distributions. Current loadings and voltage profile in distributions. Comparison of copper efficiencies in different systems of distribution.

Power transformers, theory of operation, phasor diagram, equivalent circuit. Efficiency and regulation.

Principles of energy conversion; Basic concepts of rotating machines, torque and emf; d.c. machines, characteristics of series, shunt and compound motors and generators.

Basic principles of operation of synchronous and induction machines. Starting of induction motors. Regulation of synchronous generator by synchronous impedance method.

Single-phase induction and commutator machines.

Recommended Books

- S Choudhuri, R Chakrabarti and P K Chattopadhyay. Electrical Science. The Institution of Engineers (India) Textbook Series, Narosa Publishing House, New Delhi.
- A H Cotton. Transmission and Distribution. ELBS edition. (For Group B, first para of the syllabus only.)
- N Parker Smith. Problems in Electrical Engineering. CBS Publishers and Distributors, New Delhi.

SECTION A (Diploma Stream)

AD 301

FUNDAMENTALS OF DESIGN AND MANUFACTURING

Group A

Engineering design process and its structure. Identification and analysis of need, product design specifications, standards of performance and constraints.

Searching for design concepts; morphological analysis, brainstorming. Evaluation of design concepts for physical reliability, economic feasibility and utility.

Detailed design; design for manufacture, assembly, shipping, maintenance, use, and recyclability.

Design checks for clarity, simplicity, modularity and safety. Standardization and size ranges. Reliability and robust design. Design organisation and communication, technical reports, drawings, presentations and models.

Concept of manufacturing; classification of manufacturing processes. Fundamentals of casting. Basic understanding of commonly used casting processes (sand casting, investment casting and permanent mould casting processes).

Fundamentals of metal forming; hot and cold working; basic understanding of primary metal forming processes (rolling, forging, extrusion and drawing processes, punching and blanking).

Group B

Fundamentals of metal cutting; tool-work interaction for production of machined surfaces. Classification of machining processes. Basic machining operations (turning, shaping, planning, drilling and milling processes).

Fundamentals of grinding and finishing; overview of unconventional machining processes; fundamentals of welding processes; introduction to primary welding and allied processes; selection of manufacturing processes. Design for manufacturability.

Need for integration—commercial, economic and technological perspective; basic tools of integration; concept of a system. Introduction to information technology and its elements.

Introduction to group technology; introduction to simulation and database management systems.

Elements of integration—controllers, sensors, robots, automated machines, AGVs, AS, RS, etc.

Product and process design for integration; design for economic manufacturing; design for manufacturing integration.

Introduction to computer aided process planning; selection of machine tools.

Recommended Books

□ G K Lal, Vijay Gupta and N Venkat Reddy. Fundamentals of Design and Manufacturing. Narosa Publishing House, New Delhi.

□ Surendra Kumar and M K Tiwari. Fundamentals of Design and Manufacturing. IEI Study Material.

Reference Books

□ G Dieter. Engineering Design. McGraw-Hill International.

□ G K Lal and S K Choudhary. Fundamentals of Manufacturing Processes. Narosa Publishing House, New Delhi.

□ S K Vajpayee. Principles of Computer Integrated Manufacturing. Prentice-Hall of India (P) Ltd., New Delhi.

AN 202

MATERIAL SCIENCE AND ENGINEERING

Group A

Introduction to materials. Metal and alloys, ceramics, polymers and semiconducting materials—introduction and application as engineering materials.

Defects in solids. Point, line and surface defects. Diffusion in solids.

Phase diagrams. Monocomponent and binary systems, non-equilibrium system, phase diagram and application in crystalline and non-crystalline solids.

Mechanical properties. Tensile strength, yield strength, elastic and viscoelastic properties, creep, stress relaxation and impact. Fracture behaviour. Ductile fracture, Griffith theory, effect of heat treatment and temperature on properties of metals.

Deformation of metals. Elastic and plastic deformation, slip, twin, dislocation theory, critical resolved shear stress, deformation in polycrystalline materials, strain cracking, Bacher's effect, strengthening mechanisms, work hardening recovery, crystallisation and grain growth, cold and hot working.

Group B

Heat treatment. Iron-carbon system. Annealing, normalising, hardening, critical cooling rate, hardenability, age hardening, surface hardening, tempering.

Thermal properties. High temperature materials, materials for cryogenic application, thermally insulating materials. (Specific heat, thermal conductivity, thermal expansion).

Ceramic materials and polymers. Silicon structures, polymerism fraction in glass, electrical properties of ceramic phases, rocks, building stones, refractories.

Polymerisation mechanism, structural properties of polymer, thermoplastics, thermosets, elastomer, resins, composites.

particle and fibre reinforced composite. Composite material including nano material.

Electronic properties. Magnetism, diamagnetism, paramagnetism, ferromagnetism, magnetic energy, zone theory of solids, zones in conductors and insulators.

Recommended Books

- ❑ MP Poonia and Gupta, *Material Science and Engineering*. Khanna Book Publishing, Delhi
- ❑ V Raghavan, *Material Science and Engineering*. Prentice-Hall of India (P) Ltd., New Delhi.
- ❑ SDutta and D Das *Materials Science and Engineering*. IET Study Material.

AD 303

COMPUTING AND INFORMATICS

Group A

Programming languages. C including C++; Languages—declarations, expressions, control statements, arrays, functions, pointers and structures; Algorithms and flow-charts. Introduction to Pascal.

Informatics. Information systems for decision making; Data management and database management technology; Office automation system—LAN, WAN, electronic mail, electronic data interchange; client server technology; overview of TCP/IP; Information systems for business; Strategic information systems; Information resources management.

Group B

Computer basics. History, generations and classification of computers; Number systems; Boolean algebra.

Hardware. Introduction to logic gates and flip flops; components of a computer input/output devices, CPU unit and memory unit, secondary storage.

Software. System software; application software; compilers and translators.

Operating systems. Introduction to operating systems; types of operating systems and their functions; popular operating systems—MS-DOS, UNIX and Windows; file management.

Recommended Books

- ❑ P B Mahapatra. *Computing and Informatics*. IET Study Material.
- ❑ D K Basu, et al. *Computer Systems and Data Analysis*. Narosa Publishing House, New Delhi.
- ❑ NS Gill, *Handbook of Computer Fundamentals*. Khanna Book Publishing Co. Ltd., New Delhi.
- ❑ P B Mahapatra. *Thinking in C++*. Khanna Book Publishing Ltd., New Delhi.

AD 304

SOCIETY AND ENVIRONMENT

Group A

Society

Societal Structures and Dynamics

An analysis of basic sociological concepts and their applications to contemporary society; social stratification, caste, class, cultural heritage, occupation, mobility and income distribution. Social tensions and their causes; societal responsibilities and social institutions.

Development Processes

Parameters for development. Interrelationship between social, economic and scientific factors. Role of science and technology in development. Planning—its objectives and assessment.

Technology Assessment

Historical development of science and technology. Criteria for assessment of appropriate technology and technology adaptation.

Group B

Environment

Ecosystems

Natural ecosystems. Principles of ecobalance. Biosphere cycle, carbon dioxide cycle. Causes for ecoimbalance—its effects and remedies.

Environmental Degradation

Causes for degradation—its effects. Control of air, water, soil and noise pollutions. Protection of ozone layer.

Waste Management

Agricultural, urban and industrial wastes.

Sustainable Development

Definition and concept. Technology for sustainable energy and materials.

Recommended Books

- ❑ SC Naik and T N Tiwari. *Society and Environment*. Oxford & IBH Publishing Co. (P) Ltd., New Delhi.
- ❑ MP Poonia. *Environmental Studies* (khannabooks.com)
- ❑ R Sharan, et al. *Engineering, Environment & Society*. The Institution of Engineers (India), Kolkata

Ancientness

Chemical Engineering has its roots in the chemistry of materials and engineering for equipment design. The great alchemist Jabir ibn Hayyan (8th century AD) of Baghdad combined sulphur and mercury to obtain cinnabar. He also discovered nitric acid. Wood products like bark and wood ash were in use as chemical agents from ancient times. Florence became known for his dyeing process before the fourteenth century and also worked on indigo and alum. Berthollet (1748-1822) used chlorine as a bleaching agent. A paper mill was started in England by the middle of the 16th Century. The first chemical text-book, *Al Chemia*, appeared in 1597. Hofmann set a new trend in chemical technology in Britain and the process developed by Ernest Solvay (1838-1922) constitutes a landmark in this technology. Thereafter, there had been a wide application of chemical engineering.

Impact of Minerals

In 1901, Dr William M Burton initiated pioneer work on the cracking of mineral oil. Rapid industrialisation and increased use of coal and petroleum gave a new direction and scope for chemical engineers to develop within a short span of time various new products like synthetic rubber, latex, paints, plastics, fertilizers, and teflon for wide ranging uses at home, agriculture and industry.

Current State & Status in Analysis-Synthesis Duality

Modern chemical engineering may be defined as a subject in which the four rate processes of heat, mass and momentum transfers, and of chemical or biochemical change are interrelated with conservation equations and the laws of thermodynamics to provide an understanding of phenomena taking place in process equipment and process plant (analysis). The acquired knowledge forms the basis for design of equipment and plant (synthesis) in a way which leads to streamlined and safe production of a

product with due concern for the environment.

Engineering Versus Technology

Chemical engineering in its wider concept represents a thread which is common throughout the process industries, while chemical technology deals with specific features of individual processes. By its nature, chemical engineering is outward looking and versatile whereas chemical technology, on account of its product orientation, is inward looking.

“Chemical engineering runs through the whole range of manufacturing industry, while applied chemistry simply touches the fringe of it and does not deal with the engineering difficulties even in the slightest degree, while chemical technology results from the fusion of the studies of applied chemistry and chemical engineering, and becomes specialized as the history and details of certain manufactured products.”

—G E Davis (1850–1907)

The Catalyst of Indian Economy

The chemical industry plays a pivotal role in the Indian economy. The past few years have witnessed a rapid growth in the field of chemicals with heavy organic and inorganic chemicals forming the basic building blocks for the manufacture of downstream products like drugs, dyestuffs, pesticides, plastics and paints.

The organic chemical industry was started in India around 1950 with the use of ethyl alcohol from molasses and benzene from coke ovens. At present, a substantial part of the industry is based on chemicals derived from petroleum refineries. All basic organic and inorganic chemicals are now manufactured in the country and a position of near-self-sufficiency has been achieved.

Some of the national level organisations in the field are: National Chemical Laboratory, Pune; Central Electrochemical Research Institute, Karaikudi; Indian Drugs & Pharmaceuticals Ltd, Rishikesh; Hindustan Antibiotics Ltd, Pune; Indian Petrochemicals Corporation Ltd, Vadodra; Central Institute of Plastic Engineering and Tools (CIPET), Chennai; Petrofils Cooperative Ltd, Vadodra.

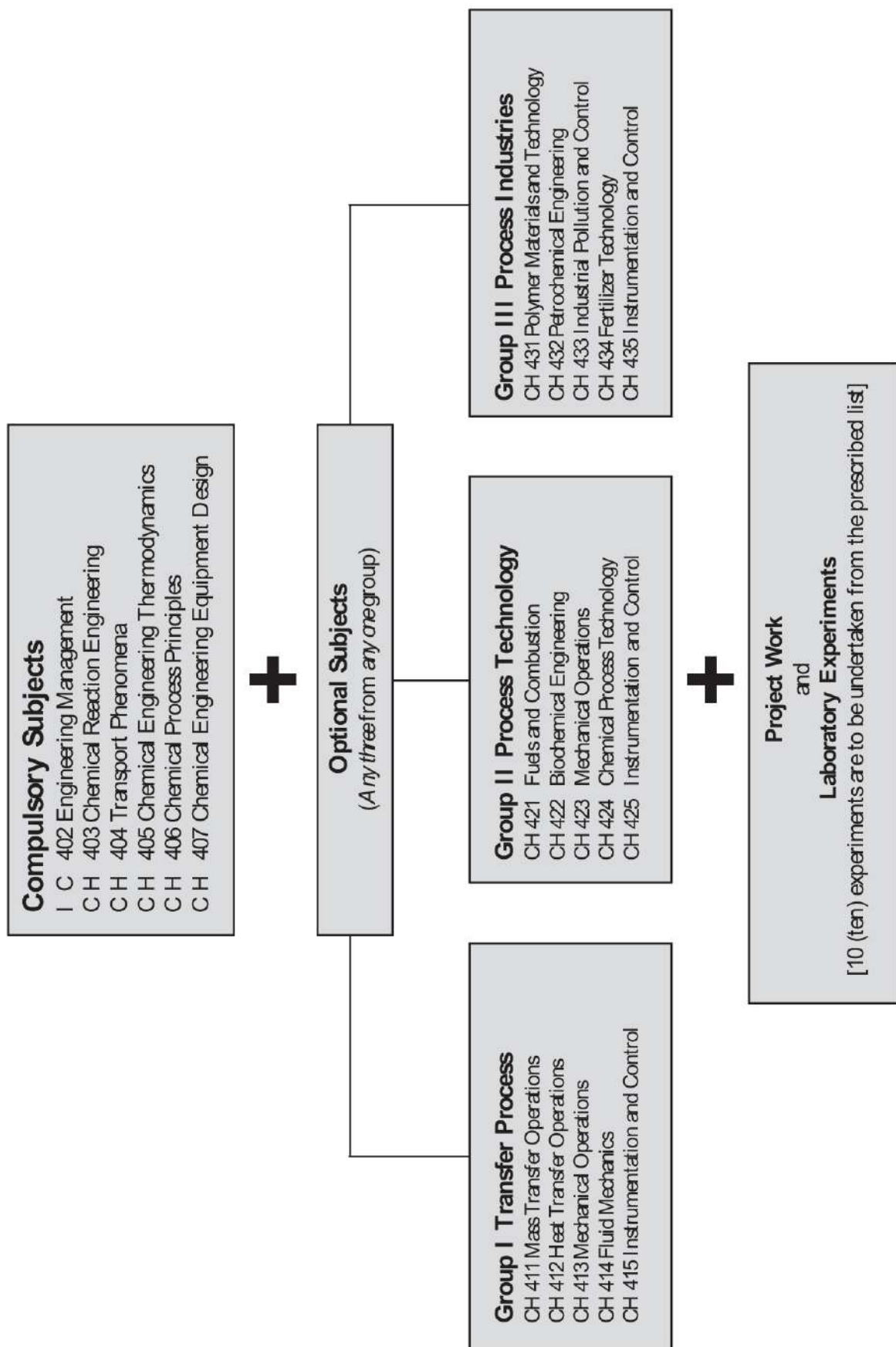
Future Role of Chemical Engineers

By the year 2020 AD, many of the present products and processes will be replaced by newer products and processes. To prepare and develop chemical engineers for this new work environment, it is important to remember that a graduate chemical engineer should have the attributes of ‘liberal education’, a ‘receptive mind’, a ‘scientific attitude’, and a ‘clear awareness’ of his role as a professional in the society.



A Chemical Complex

CHEMICAL ENGINEERING



CHEMICAL ENGINEERING

IC 402

ENGINEERING MANAGEMENT

Group A

Management and Organisations

Management process : Definition, planning, organising, directing, controlling, coordinating, types of management.

Organisation: Definition, planning, design and development, types of organisations.

Management planning and control: Classical, new classical and modern principles. General management, scientific management, engineering management, systems management.

Planning: Procedures, resources and constraints, objectives, goals, policies and procedures.

Control : Setting of reference or standards, appraisal or evaluation, monitoring and controlling, types of control.

Human resource planning and management. Selection, recruitment, training, retraining, skill development, competence development, promotion and career development, participative management, trade unions, and collective bargaining.

Management of Physical Resources

Plant: Site selection procedures, factors affecting selection. Layout—types and relative merits and demerits. Maintenance—objectives, different types of associated decisions, strategies for effective maintenance, computer applications.

Material : Functions, objectives, planning and control including inventory models with or without storage costs, price break (excluding dynamic and probabilistic considerations). Different classes of inventory. Material Requirement Planning (MRP).

Group B

Financial management: Introduction to standard forms of financial statements, i.e., balance-sheet, profit and loss, and income statement. Fixed and current asset items. Fixed and current liability items. Linkage of two successive balance-sheets through income or profit and loss statement. Funds flow statement. Financial ratios and their implications.

Managerial economics: Concepts, theory of production, marginal productivity and cost. Introduction to theory of firm.

Quality management: Quality definition, quality planning, quality control and quality management. Total quality management, ISO 9000 systems, simple quality control techniques like control charts and acceptance sampling.

Marketing management. Consumer behaviour, market research, product design and development, pricing and

promotion.

Project management. Introduction. Concept of a project, project management concepts, project formulation, cost of project and means of financing, economic evaluation criteria of the project, project implementation, project planning, scheduling and monitoring, project control (PERT, CPM techniques including crashing), project evaluation.

Information technology and management. Role of information, management information system and decision support system. Information technology—introduction to e-business, e-commerce and integration tools like enterprise resource planning (ERP).

Recommended Books

.. A K Gupta. Engineering Management. S Chand & Co. Ltd., New Delhi.

.. S Datta and Mansoor Ali. Industrial Engineering and Management Systems. Standard Publishers & Distributors, Delhi.

.. SC Sharma. Engineering Management, khannabooks.com

.. E S Buffa. Modern Production/ Operations Management. New Age International (P) Ltd., New Delhi.

CH 403

CHEMICAL REACTION ENGINEERING

Group A

Classification of reactors and reactions. Definition of reaction rate, variables affecting the rate. Rate theories—the Arrhenius relationship. Collision theory and activated complex theory.

Order of reaction and its determination. Interpretation of kinetic data for batch and flow systems. Integral and differential methods of analysis.

Design of batch, semi-batch and flow reactors for ideal single reactions, reaction in series and in parallel and mixed reactions—all under isothermal conditions.

Group B

Comparison of performance of CSTR with PFR. The effect of volume change during the reaction. Reactive distillation. Membrane reactors. Introduction to design of adiabatic and non-isothermal reactors. Kinetics and typical examples of uncatalyzed heterogeneous reactions.

Properties of catalysts and their determination. Classification of catalysts. General procedure for manufacture of catalysts. Promoters, inhibitors and poisons. Mechanism of catalyzed reactions. Design of fixed bed and fluidized bed catalytic reactors under isothermal conditions.

Introduction to non-ideal reactors. Residence time distribution, dispersion model and its solution for different boundary conditions.

Recommended Books

- .. J M Smith. Chemical Engineering Kinetics. McGraw-Hill International.
- .. O Levenspiel. Chemical Reaction Engineering. McGraw-Hill International.

CH 404

TRANSPORT PHENOMENA

Group A

Momentum transport: Physical properties of fluids, forces on fluids, buoyancy, hydrostatic equation for compressible fluids. Laws of viscosity. Types of fluid motion—flow through pipes and channels. Bernoulli's theorem. Conservation of mass and momentum head loss in fittings. Solution of pipe flow problems. Differential balances in Cartesian coordinates. Navier-Stokes equation. Solution of Navier-Stokes equation for simple cases. Creeping flow.

Turbulent flow: Nature and intensity of turbulence. Universal velocity distribution. Flow through rough pipes. Boundary layer flow solution for laminar and turbulent flows. Flow past immersed bodies. Application of dimensional analysis in fluid dynamics.

Group B

Energy transport. Thermal conductivity. Steady and unsteady state heat conduction in one-dimensional system. Convective heat transfer coefficients. Heat transfer with laminar flow over a flat wall and through pipes. Heat transfer with turbulent flow. Condensation and boiling heat transfer. Analogies between momentum and heat transfer.

Mass transport: Theories of diffusion. Component mass balance. Convective mass transfer coefficients. Mass transfer with laminar flow and with turbulent flow over a flat wall. Analogies between momentum and mass transfer. Simultaneous momentum, heat and mass transfer.

Recommended Books

- .. R B Bird, W E Stewart and E N Lightfoot. Transport Phenomena Wiley International.
- .. C O Bennett and J E Myers. Heat and Momentum Transport. McGraw-Hill International.

CH 405

CHEMICAL ENGINEERING THERMODYNAMICS

Group A

First law. Evaluation of P-V-T properties of fluids. Law of

corresponding state. Residual volume, compressibility factor. Equations of state. Heat effects. Clausius-Clapeyron equation.

Second law. Entropy. Carnot cycle, work function, free energy. Phase rule—its use in study of multicomponent systems.

Group B

Refrigeration. Thermodynamic efficiency, production of work from heat. Partial molal properties. Chemical potential, fugacity.

Activity and activity coefficients. Gibbs-Duhem equation. Determination of activity coefficients from van Laar equations. Chemical reaction equilibria. Introduction to Third Law.

Recommended Books

- .. J M Smith and H C Van Ness. Introduction to Chemical Engineering Thermodynamics. McGraw-Hill International.
- .. E Balzhiser and R Samuels. Engineering Thermodynamics. Prentice-Hall of India (P) Ltd., New Delhi.

CH 406

CHEMICAL PROCESS PRINCIPLES

Group A

Graphical methods of curve fittings, method of least squares, solution of cubic equations by trial and error method. Conversion of units. Dimensional analysis. Properties of gas, liquid and solid. Equations of state.

Vapour pressure. Vapour pressure plots, vapour pressure of immiscible liquids and vapour pressure of solutions. Humidity and saturation humidity chart. Super saturation. Distribution of a solute between immiscible and partially miscible liquids. Solubility of gases.

Group B

Materials balance: Concepts of limiting and excess reactants, batch, stage-wise, continuous and recycle operations. Material balance of systems involving mixing, extraction, distillation, crystallization, chemical reaction and recycle processes.

Heats of formation, combustion, reaction, solution, dilution, etc. Effect of temperature on heat of reaction. Energy balance of systems without and with chemical reactions. Material and energy balance calculations for simple processes like manufacture of sulphuric acid, nitric acid and alkali.

Recommended Books

- .. O A Hougen, K M Watson and R A Ragatz. Chemical Process Principles—Part I. Asia Publishing House, Mumbai.
- .. S K Ghoshal, S K Sanyal and S Dutta. Introduction to Chemical Engineering. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. B I Bhatt and S M Vora. Stoichiometry. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

CHEMICAL ENGINEERING EQUIPMENT DESIGN

Group A

Process equipment supports. Storage tanks and pressure vessels.

Heat transfer equipment. Concentric pipe, shell and tube, single-pass and multi-pass heat exchangers; Condensers.

Group B

Single and multiple effect evaporators. Plate and frame filter press.

Mass transfer equipment. Absorption and distillation columns; Rotary dryers.

Recommended Books

- .. D Q Kern. Heat Transfer. McGraw-Hill International.
- .. R E Treybal. Mass Transfer Operations. McGraw-Hill International.
- .. R K Snnett. An Introduction to Chemical Engineering Design in Chemical Engineering: Vol 6. Coulson and Richardson Series, Pergamon Press, Oxford.

MASS TRANSFER OPERATIONS

Group A

Principles and theories of mass transfer. Mass transfer coefficients and their correlations. JD factor and HTU concepts. Absorption, principles, packing materials. Flooding and loading points. HETP and HTU concepts. Absorption concepts and qualitative treatment.

Distillation: Batch, continuous, flash, vacuum, steam, molecular, azeotropic, extractive and multi-component distillation. Theory of fractional distillation of binary mixtures. Calculation of number of theoretical plates. Plate efficiency. Minimum and optimum reflux.

Group B

Crystallization: Factors influencing nucleation and crystal growth. Caking of crystals. Different crystallizers and their design principles.

Extraction: Batch and continuous. Calculation of number of ideal stages. Multistage extraction. Equipment and their design principles.

Drying: Theory and mechanism of drying, drying rates, different dryers and their design principles. Wet and dry bulb hygrometry. Humidification and dehumidification. Air-conditioning. Cooling.

Recommended Books

- .. R E Treybal. Mass Transfer Operations. McGraw-Hill

International.

- .. W L McCabe and J C Smith. Unit Operations of Chemical Engineering. McGraw-Hill International.

HEAT TRANSFER OPERATIONS

Group A

Fouriers' laws of conduction, steady state conduction of heat through solids. Steady state heating and cooling of liquids. Convection-free and forced, heat transfer correlations—free and forced. Heat transfer from vertical surfaces and rotating bodies.

Heat transfer from condensing vapours and boiling liquids—filmwise and dropwise. Boiling coefficients. Fouling factors. Heat exchange equipment like heat exchangers, condensers and waste heat boilers. Heat transfer in stirred tanks.

Group B

Heat transfer by radiation—black body and grey body radiation, laws of radiation. Shape factor. Combined heat transfer coefficients with convection and radiation.

Evaporation: Various types of evaporators and their attachments, performance of evaporators, boiling point rise. Single and multiple effects. Forward feed, backward feed and mixed feed. Vapour compression evaporation. Barometric condensers.

Recommended Books

- .. D Q Kern. Process Heat Transfer. McGraw-Hill International.
- .. W L McCabe and J C Smith. Unit Operations of Chemical Engineering. McGraw International.
- .. S P Sukhatme. A Textbook on Heat Transfer. Orient Longman Ltd., New Delhi.

MECHANICAL OPERATIONS

Group A

Classifications and performance of pumps, blowers, compressors and turbines—their selection and specifications. Mechanical and pneumatic conveying equipment and power consumption. Design of conveyor belts.

Theories of filtration—constant rate and constant pressure filtration. Optimum cycle, compressible cakes and filter aids. Centrifugation. Flow through packed beds. Fluidization.

Group B

Size reduction—types of equipment and their studies. Closed and open circuit grinding. Laws of crushing and grinding, power requirements. Screening—equipment and efficiency. Sedimentation—free and hindered setting. Cyclones and electrostatic precipitator. Flotation. Thickeners.

Mixing equipment and characteristics, power consumption and efficiency. Measurements of fluid flow by weir, V-notch, orifice meter, venturi meter, pitot tube and rotameter.

Recommended Books

- .. W L McCabe and J C Smith. Unit Operations of Chemical Engineering. McGraw-Hill International.
- .. A M Gaudin. Principles of Mineral Dressing. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

CH 414

FLUID MECHANICS

Group A

Introduction. Shear stress, viscosity, kinematic viscosity, dependence of viscosity on temperature and pressure. Ideal fluid.

Fluid statics: Pressure hydrostatics. Forces on submerged surfaces and bodies. Manometers. Dimensional analysis and similitude. Buckingham Pi theorem, methods to determine dimensionless groups. Reynold, Froude and Mach numbers.

General description of fluid motion. Types of flows, streamlines and stream tubes. Dynamics of fluids in steady motion. Equation of continuity and momentum, momentum correction factor. Bernoulli's equation. Application of continuity, momentum and Bernoulli's equation to physical situations.

Group B

Flow in pipes, Poiseuille's equation; kinetic energy correction factor; friction factor; hydraulic radius; D'Arcy-Weisbach formula. Equivalent resistance of valves and fittings. Expansion and contraction losses.

Flow around immersed bodies. Boundary layers—laminar and turbulent. Pressure distribution. Drag and lift-form drag; drag coefficient; drag coefficient as a function of Reynold's number. Stoke's law. Terminal velocity. Compressible flow: Qualitative treatment only.

Recommended Books

- .. W L McCabe and J C Smith. Unit Operations of Chemical Engineering. McGraw-Hill International.
- .. V L Streeter and E B Wylie. Fluid Mechanics. McGraw-Hill International.
- .. Sadhu Singh. Fluid Mechanics. Khanna Book Publishing (P) Ltd., New Delhi.

CH 415

INSTRUMENTATION AND CONTROL

Group A

Temperature measuring instruments. Bimetallic, vapour pressure, thermocouples, resistance thermometer, radiation pyrometer, optical pyrometer, photoelectric pyrometer,

thermistor. Response of these instruments. Instrument performance characteristics and evaluation.

Composition measuring instruments. Spectroscopic method, thermal conductivity cell, carbon dioxide analyser, fuel gas analysis, oxygen analysis, pH meter, refractometer, chromatograph, colorimetry and polarograph. Response of these instruments. Instrument performance characteristics and evaluation.

Measurement of pressure and volume. Manometer, pressure spring McLeod gauge, Pirani gauge, ionisation gauge and liquid seals. Response of these instruments. Viscosity measurement, specific gravity measurement, level measuring devices, flow measuring devices, measurement of displacement and density.

Group B

Transfer functions and input-output models. Dynamic response to step inputs of first and second order systems with or without time lags. Feedback control and effect of proportional, integral and derivative control.

Root-locus analysis and stability of feedback controlled systems. Frequency response of systems. Bode diagrams. Ziegler-Nichols methods.

Recommended Books

- .. D P Eckman. Industrial Instrumentation. New Age International (P) Ltd., New Delhi.
- .. DC Sikdar. Instrumentation Process & Process Control. Khanna Book Publishing Co. Ltd., New Delhi.
- .. A Suryanarayana. Outlines of Chemical Instrumentation and Process Control. Khanna Publishers, Delhi.

CH 421

FUELS AND COMBUSTION

Group A

Introduction to different energy sources—conventional and non-conventional.

Coal technology: Origin of coal, its classification. Washing, briquetting and carbonization.

Liquid fuels. Petroleum and prepared liquid fuels. Synthetic liquid fuels. Storage, handling, utilization and testing.

Group B

Gaseous fuels: Natural gas, LPG, manufactured gases such as producer gas, water gas and hydrogen. Coal gasification.

Combustion and furnaces. Stoichiometry, combustion thermodynamics, propagation of flame and combustion appliances. Fluidized bed combustion. Elementary concepts of furnace design. Regenerators and recuperators.

Recommended Books

- .. SP Sharma and M Chander. Fuels and Combustion. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

.. S Sarkar. Fuels and Combustion. Orient Longman Ltd., New Delhi.

CH 422

BIOCHEMICAL ENGINEERING

Group A

Scope and importance of biochemical engineering and biotechnology. Micro-organisms: Structures, composition and activity. Kinetics of cell growth—Monod equation.

Metabolic pathways and bioenergetics.

Enzymes: Biocatalysts, immobilized enzymes, enzyme kinetics—Michel-Menten equation. Sequential enzyme reactions, regulation of enzyme activity.

Group B

Transport phenomena in microbial systems. Fermentation: Process parameters, sterilization. Process control.

Bioreactors: Different types—design and scale up. Cellular genetic, genetic manipulation, principles of recombinant DNA technology. Important biochemical products—their manufacturing procedures and uses.

Recommended Books

.. F C Webb. Biochemical Engineering. Van Nostrand Publishing Co.

.. J E Bailey and D F Ollis. Biochemical Engineering Fundamentals. McGraw-Hill International.

CH 423

MECHANICAL OPERATIONS

(See page 15, subject CH 413)

CH 424

CHEMICAL PROCESS TECHNOLOGY

Group A

Water for industries and water treatment: Boiler feed water, cooling tower water and process plant water. Water treatment by lime-soda process, flocculation, aeration, deaeration and ion exchange methods. Acid industries: Sulphuric, hydrochloric, nitric and phosphoric acids. Alkali industries: Caustic soda, sodium carbonate, chlorine and bleaching powder.

Fertilizers: Nitrogenous, phosphatic and potassic—raw materials and manufacturing processes. Mixed and compound fertilizers. Superphosphates. Bio-fertilizers.

Group B

Glass, ceramics, cement and refractory industries. High polymers, including plastics, rubber and fibres—their chemistry and technology. Petroleum refinery and petrochemicals.

Oils and fats: Refining, hydrogenation, fat splitting. Soaps and detergents. Pulp and paper industries. Industrial fermentation—ethyl alcohol.

Recommended Books

.. R N Shreve. Chemical Process Industries. McGraw-Hill International.

.. M Gopal Rao and M Sittig. Dryden's Outlines of Chemical Technology. Affiliated East-West Press (P) Ltd., New Delhi.

.. OP Gupta. Chemical Technology. Khanna Publishing, New Delhi.

CH 425

INSTRUMENTATION AND CONTROL

(See page 16, subject CH 415)

CH 431

POLYMER MATERIALS AND TECHNOLOGY

Group A

Genesis of polymers, chemistry of polymerisation. Chain and step polymerisation, polymerisation techniques. Copolymerisation.

Kinetics of polymerisation, molecular weight, glass transition temperature. Crystallinity.

Polymer rheology. Viscosity, apparent viscosity, Newtonian and non-Newtonian fluid, power law, viscoelastic behaviours.

Polymer characterisation. Polymer synthesis, molecular weight method gpc, thermal analysis.

Polymer degradation. Thermal, mechanical, UV radiation, oxidative and hydrolytic degradation.

Group B

Plastic material and processing technology. Polyethylene, polypropylene, polystyrene, PVA, PVC, polyurethane.

Plastic processing. Mixing, molding, extrusion. Rubber material and processing technology. Natural and synthetic rubber. Thermoplastic elastomers.

Rubber processing: Compounding, vulcanisation (mixing), molding, extrusion, calendaring.

Identification, testing and evaluation of plastic and rubber. Identification of common plastics and rubbers.

Physical testing—stress-strain, tear, hardness, resilience. Flexing, abrasion, and impact testing. Electrical properties. Resistivity, dielectric constant, power factor.

Recommended Books

.. P Ghosh. Polymer Science and Technology. Tata McGraw Publishing Co. Ltd., New Delhi.

- .. F B Billmeyer. Textbook of Polymer Science. Wiley Interscience, New York.
- .. J R Fried. Polymer Science and Technology. Prentice-Hall of India (P) Ltd., New Delhi.
- .. V R Gowarikar, N V Viswanathan and J Sreedhar. Polymer Science New Age International (P) Ltd., New Delhi.

CH 432

PETROCHEMICAL ENGINEERING

Group A

Origin, occurrence, composition and physical properties of petroleum. Evaluation of oil stocks. Petroleum refining processes—topping and vacuum distillation. Thermal cracking—vapour phase, liquid phase and mixed phase. Thermal reforming and polyforming. Catalytic cracking—fixed bed, fluidized bed and TCC. Catalytic reforming.

Conversion of petroleum gases into motor fuel with special reference to alkylation, polymerization, hydrogenation and dehydrogenation. Production of aviation gasoline, motor fuel, gasoline, kerosene, distillates, diesel oil, tractor fuel, jet fuel and fuel oil. Octane number, cetane number, diesel index—their determination and importance.

Group B

Lube manufacture—vacuum distillation, solvent extraction, uses of lubes. Petroleum waxes. Chemical and clay treatment of petroleum products. Natural gas. Carbon black.

Petrochemicals—manufacture of a few important petrochemicals and their uses. Elementary study of multicomponent distillation as applied to petroleum refineries. Specifications and testing of refinery products.

Recommended Books

- .. W L Nelson. Petroleum Refinery Engineering. McGraw-Hill International.
- .. O P Gupta. Elements of Petrochemical Engineering. Khanna Publishing, Delhi.
- .. B K Bhaskara Rao. Modern Petroleum Refining Processes. Oxford and IBH Publishing Co (P) Ltd., New Delhi.

CH 433

INDUSTRIAL POLLUTION AND CONTROL

Group A

The ecosystem. Effect of polluted environment on ecosystem. Classification of pollutants. Sources of pollutants. Toxic chemicals and other industrial wastes. Methods of estimation of pollutants.

Approach to air pollution control. Pollution control techniques with reference to gaseous, liquid and solid pollutants.

Control equipment for particulate emission. Solid waste treatment and management. Pollution control with recycling.

Group B

Wastewater and sludge treatments. Treatment of industrial wastes from typical chemical industries. Pollution control in industries like acid, alkali, fertilizer, paper and pulp, food, petrochemicals, leather tanning and brewery industries.

Elementary microbiology related to pollution and pollution control. Aerobic and anaerobic processes. Pollution control legislation.

Recommended Books

- .. G N Pandey and G C Carrey. Environmental Engineering. Tata McGraw-Hill Publishing Co Ltd., New Delhi.
- .. O P Gupta. Elements of Environmental Pollution Control. Khanna Publishing Co. Ltd., New Delhi.

CH 434

FERTILIZER TECHNOLOGY

Group A

Soil fertilizer interaction. Importance of fertilizers. Fertilizers recommended for various crops.

Nitrogenous fertilizers. Feed stock for ammonia production and synthesis gas production—production procedures. Manufacture of ammonia, urea and other nitrogenous fertilizers.

Phosphatic fertilizers. Raw materials, single and triple superphosphate manufacture.

Potassic fertilizers. Raw materials and sources. Production of important potassic fertilizers.

Group B

Mixed N-P-K fertilizers, granulated fertilizers and compound fertilizers—production procedure.

Micronutrients. Production and applications.

Organic fertilizers. Compost and biofertilizers, comparative study with chemical fertilizers.

Pollutional problems in fertilizer industries and their control.

Recommended Books

- .. R N Shreve. Chemical Process Industries. McGraw-Hill International.
- .. M Gopal Rao and M Sitting. Dryden's Outlines of Chemical Technology. Affiliated East-West Press (P) Ltd, New Delhi.

CH 435

INSTRUMENTATION AND CONTROL

(See page 16, subject CH 415)

Civilization—The Other Name of Engineering

Ancient monumental buildings, roads, aqueducts, etc. give ample evidence of 'Civil Engineering' work of the past. Mohenjodaro and Harappa of 2500 BC with planned buildings, streets and even sewer systems come in contrast to modern cities. The ancient Egyptians and Sumerians also constructed effective canals and irrigation systems.

In Egypt, the boundaries of land were fixed after seasonal floods by 'surveyors' having knowledge of geometry. The Romans laid road over 80000 km, part of which have withstood the test of time. They also used arches' or 'vaults' extensively as support structures for buildings and bridges.

As during the sixteenth century there was no differentiation between architects' and 'engineers', it was mainly on personal ability, inclination and aptitude that characterised a project executor as an artist and architect or a technician and engineer.

Cementation of Civil Engineering with the Advent of Iron & Steel

The development of technologies for iron and steel production as a consequence of the industrial revolution helped to adopt iron and steel structures for economy and accuracy in civil engineering work. A modern suspension bridge was erected in North America in 1796. During the nineteenth century, hydraulic engineering developed through the efforts of Prony, Eytewein, Darcy, Weisbach, Bazin and others. De Sazilly (1853) and Delocre (1866) outlined the basic theories for construction of dams whereas Franz Von Reber (1831-1897) invented the scientific techniques for tunnel construction. Compressed air foundation was first used by Smeaton.

Pozzolana ash, a volcanic deposit found in Italy, had long been used for the preparation of hydraulic mortar. *Construction site of a plant* Many tried to produce an efficient hydraulic agent but

an English mason and building contractor, Joseph Aspdin (1799-1855) succeeded. He called the project 'Portland Cement' to utilize the popularity of the portland stone as building material. Reinforced concrete was invented by Joseph Monier in 1867 and the first reinforced concrete bridge was constructed eight years later.

Multidimensional Engineering

Civil engineering encompasses residential, industrial and commercial buildings with a foundation suited to the geological conditions and with a reliable frame structured to support the floors, walls and roof, capable of resisting fire, wind forces and seismic shocks.

Civil engineering is also involved in the creation of efficient and economical transportation facilities and terminals on surface and water, including streets, highways, expressways and parking facilities; rapid transit systems and subways; transmission systems and pipelines; waterways, dams and harbours; airports and runways and even the most sophisticated launch facilities for vehicles to outer space. Perfect knowledge and the most creative skills are needed to meet

the critical parameters of load, topography geological considerations, social constraints, aesthetics and economy.

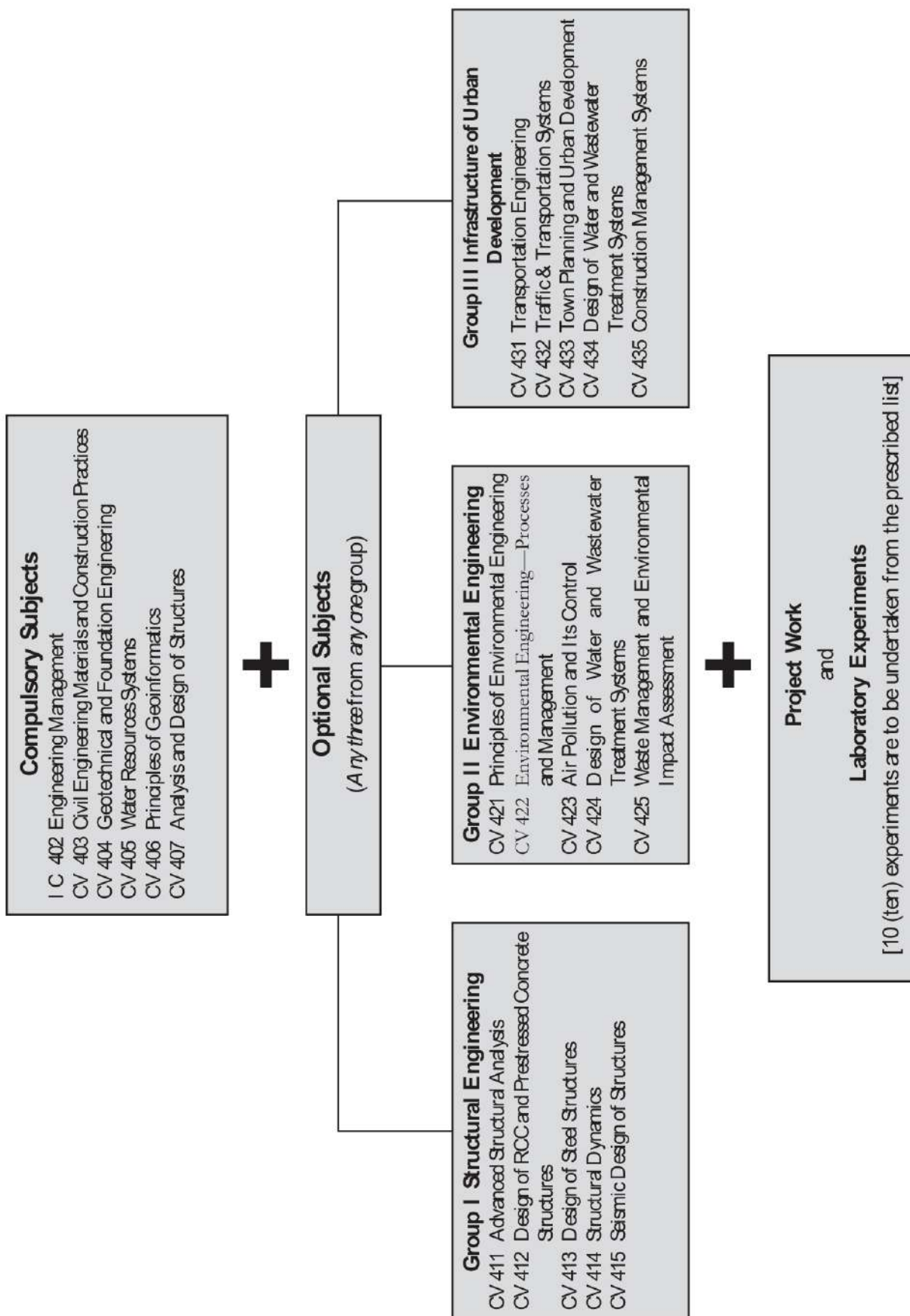
The harnessing of rivers to control floods, produce hydro-electric power and provide water for agricultural, domestic and industrial uses comprise a major area of Civil Engineering application. Ground water resource development and efforts towards exploitation of ocean resources for minerals are also important.

Civil Engineering involves the planning, design, construction and management of all types of works and facilities, including buildings and structures, transportation facilities, water resource development projects, power generation plants and other facilities to enhance the comforts of man. These activities are generally categorized as public works of the government. But the civil engineer extensively offers his expertise also to private industries and military establishments.



Construction site of a plant

CHEMICAL ENGINEERING



CIVIL ENGINEERING

IC 402

ENGINEERING MANAGEMENT

(See page 13, subject IC 402)

CV 403

CIVIL ENGINEERING MATERIALS AND CONSTRUCTION PRACTICES

Group A

Introduction to civil engineering materials—stone, timber, cement, steel, plastics, concrete. Engineering properties of materials—density, strength (compressive, tensile, flexural, shear, etc.), modulus of elasticity, fatigue, limit, creep, shrinkage, relaxation, permeability, fire resistance. Materials and environment—effect of environment on materials. Classification of environment—temperature, humidity, rain, fire.

Steel: Manufacture, rolled sections, properties, classifications.

Cement: Manufacture—wet and dry processes, constituents and constitution, properties—setting, strength, durability, classification—high early strength, low alkali, rapid hardening.

Concrete: Constituents—coarse and fine aggregates, cement, water. Mineral admixtures—flyash, blast furnace slag, silica fume. Chemical admixtures—air entraining, set retarding and accelerating, super plasticising. Fresh concrete—workability, air content, segregation. Hardened concrete—strength, hardness, modulus of elasticity, modulus of rupture.

Special concretes—fibre, reinforced, shotcrete, underwater, high strength. Deterioration and durability—reinforcement, corrosion, carbonation, alkali-aggregate reaction.

Group B

Bricks: Manufacture, classification. Other materials. Standardization and standards—need to have standards and some common international standards. Relevant Indian standards (commonly used standards to be listed with brief description). Quality control. Non-destructive testing and evaluation.

Construction practices: Standards relevant to quality control at site. Safety issues. Quantities and estimation. Tender document. Contracts—unit rate, lumpsum, turnkey. Project management—CPM, PERT, bar charts, pie diagrams, escalation, depreciation.

Recommended Books

- .. A M Neville. Properties of Concrete. ELBS Publication.
- .. S C Charma. Civil Engineering Construction Materials Khanna Publishing, New Delhi.
- .. B C Punmia and K K Khandelwal. Project Planning and

Control with CPM and PERT. Laxmi Publications, New Delhi.

- .. D N Ghose Materials of Construction. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

CV 404

GEOTECHNICAL AND FOUNDATION ENGINEERING

Group A

Introduction to soil mechanics, examples of geotechnical engineering applications. Description of assemblage and individual particles, classification, etc. Soil types.

Geostatic stresses, stresses due to applied loads, stress point, stress paths, principle of effective stress. Soil-water systems, capillarity, flow through soils. Darcy's law, tests to determine the coefficient of permeability in the lab and in situ, one-dimensional flow, total elevation and pressure heads, piping/ quicksand condition.

Two-dimensional flow, seepage, continuity condition, methods of solution, confined and unconfined flows, flow nets, etc. Tests for strength and stress strain relations, stress paths.

One-dimensional compression test, compressibility parameters, maximum past consolidation pressure, OCR, phenomenon of consolidation, Terzaghi theory, coefficients of consolidation and secondary compression (creep), consolidation under construction loading, vertical drains, radial flow consolidation, etc.

Strength and triaxial testing, Mohr-Coulomb strength criterion, drained, consolidated, undrained and undrained tests, strength of sands (loose and dense) and fine grained (NC and OC) soils, partially saturated soils, volume changes (dilation and contraction) due to shear stresses.

Group B

Characterisation of ground, site investigations, methods of drilling/boring, sampling and in situ tests—SPT, CPT, plate load test and its limitations, groundwater levels, etc.

Bearing capacity of foundations, general, local and punching shear modes, theories, corrections for different conditions, ultimate and allowable pressures, methods based on in situ tests.

Settlement of foundations, one- two- and three dimensional approaches, immediate consolidation and creep settlements, stress path method, methods based on in situ tests, etc. Choice of type of foundations, shallow/ deep, isolated, combined, strap, trapezoidal or mat foundations, contact pressure, distribution, basics of footing design. Ground improvement methods,

preloading, vertical drains, vibrocompaction, stone columns, heavy tamping, etc.

Earth pressure theories, Coulomb and Rankine theories, effect of layering, water level, etc. Retaining walls, types—gravity, cantilever, counterfort, reinforced earth, etc. Design methods, checking for stability.

Recommended Books

- .. RF Craig. Soil Mechanics. ELBS/ van Nostrand, UK.
- .. C Venkataramiah. Geotechnical Engineering. New Age International (P) Ltd., New Delhi.

CV 405

WATER RESOURCES SYSTEMS

Group A

Introduction to water resources systems: Elements of a water system, concept of a system, systems analysis techniques, issues in systems approach, advantages and limitations of systems approach, challenges in water sector.

Acquisition and processing of water resources data: Types of data, design of hydromet networks, data validation, acquisition and processing of precipitation and other meteorological data, acquisition and processing of streamflow data, water quality and other data, water resource information system. Emerging techniques of data acquisition and systems modelling.

Remote sensing, geographic information systems.

Statistical techniques for data analysis: Random variable, cumulative distribution function, probability distribution function, distribution characteristics. Normal distribution, extreme value type I distribution, Gamma distribution, Pearson type III distribution, discrete probability distributions, method of moments for continuous and discrete systems, problems of parameter estimation, hypothesis testing: t-test, Chi-square distribution, linear regression, correlation analysis. Frequency analysis: frequency factor method, time-series analysis, autoregression and moving average models.

Systems analysis techniques: Optimization, Kuhn-Tucker conditions. Linear programming: Standard form, graphical solution, simplex method, duality, piecewise linearization, simulation.

Group B

Economic considerations: Basic principles of project economics, demand utility of water, project economics and evaluation, discounting techniques, benefit-cost ratio method, present worth and rate-of-return and annual cost methods, project-feasibility and optimality.

Environmental and social considerations: Water in environment, environmental impact of water resources projects,

environmental impact of reservoirs, environmental problems in command areas, environmental impact assessment, sustainable development. Social impacts.

Water resources planning: Stages in water resources planning, data collection and processing, estimation of future water demands, preliminary planning, institutional set-up, public involvement, formulation and screening of alternatives, models for water resources planning, sensitivity analysis.

Reservoir sizing: Need for reservoirs, classification of reservoirs, water uses, reservoir planning, estimation of water yield, hydro-power generation, reservoir losses, water balance of a reservoir, storage requirement for conservation purpose: Mass curve method, sequent peak algorithm, flood control storage capacity, reservoir routing.

Recommended Books

- .. SK Jain and V P Singh. Water Resources Systems: Planning and Management. Elsevier, 2003.
- .. S Vedula and P P Majumdar. Water Resources Systems. Tata McGraw-Hill Publishing Company Ltd., New Delhi.

CV 406

PRINCIPLES OF GEOINFORMATICS

Group A

Introduction to surveying: Objectives, classification of surveys, Indian topographic series, map reading.

Linear measurements: Distance measurements with chain and tapes, corrections to measured length, field survey by chains/tapes.

Compass surveying: True and magnetic bearings, local attraction, fore and back bearing, various types of compasses and applications, detail plotting, adjustment of compass traverse using graphical approach.

Levelling: Concepts of Geoid, ellipsoid, MSL and level surface, methods of levelling, determination of height, booking of levelling operation, types of levels, sensitivity of the bubble, trigonometric levelling, curvature and refraction effects.

Contouring: Guidelines for preparation of contour maps, methods of contouring. Plane Tabling (PT): Accessories in PT, methods of PT, re-section methods, preparation of map.

Theodolites: Measurements of horizontal and vertical angles, differences in Vernier and microptic theodolites, methods of recording angles.

Errors and adjustments: Accuracy and precision, propagation of variance/ covariance and adjustment of errors using observation equation and condition equation approach (matrix based solution).

Tacheometric surveys: Principle and basic system, subtense bar, various types of tachometers, plotting with tachometers.

Curves: Classification, elements of simple circular, compound, reverse, transition, vertical curves, setting of curves

Group B

Triangulation: Purpose of triangulation and trilateration, classification, strength of figure, well conditioned triangle, triangulation figures, reconnaissance and station selection, intervisibility of stations, signal and towers, base lining, computation and adjustment in triangulation, satellite station.

EDM: Principles and applications, instruments: Geodimeter, Tellurometer, Distomat, etc.

Digital Theodolites/ Total Station/ GPS: Principles and applications.

Introduction to photogrammetry: Comparison of serial photographs and topographic maps, definition of basic terms, perspective of near-vertical photograph, scale and coordinates from photographs, stereoscopy, parallel bar measurements, determination of heights, principle of radial line triangulation, assumption, limitations and errors.

Introduction to remote sensing: Remote sensing system, data-acquisition and processing, EMR and spectrum, atmospheric windows. Interaction mechanisms, multi-concept, sensors and platforms. Interpolation of aerial photographs and satellite imagery and their interaction.

Recommended Books

- .. K K Rampal. Surveying. Pragati Prakashan, Meerut (UP).
- .. K K Rampal. Text Book for Photogrammetry. Oxford & IBH Publishing Co (P) Ltd., New Delhi.
- .. JM Campbell. Introduction to Remote Sensing. Taylor & Francis, London.

CV 407

ANALYSIS AND DESIGN OF STRUCTURES

Group A

Analysis

Stability and determinacy of structures.

Review of shear force and bending moment diagrams in beams and frames.

Plane trusses: Method of joints and method of sections.

Deflection of trusses (virtual work method).

Deflection of beams and frames.

Method of virtual work by Castigliano's theorem; Moment-area method and conjugate beam method.

Influence line diagrams and moving loads.

Three-hinged arches and cables.

Analysis of statically indeterminate structures.

Force and stiffness method of analysis.

Plane truss using method of consistent deformation.

Beams and frames.

Method of consistent deformation, three-moment equation, slope-deflection equations, moment distribution method, Kani's method.

Group B

Design

Introduction.

Structural fasteners (rivets, welds, bolts).

Design of tension members.

Design of compression members.

Design of beams (rolled section, build-up sections).

Design of bolted (eccentric) connections.

Design of welded plate girder.

Design of industrial buildings (cantry girder, roof trusses, etc).

Design of beam—columns and column bases.

Design of RCC beams, columns, slabs and footings by working stress method of design.

Recommended Books

- .. S P Timoshenko and D H Young. Theory of Structures. McGraw-Hill International.
- .. R Agor. Structural Analysis. Khanna Book Publishing Co., (P) Ltd., Delhi.
- .. P Dayaratnam. Design of Steel Structures. S Chand & Co. Ltd., New Delhi.
- .. J E Bowles. Structural Steel Design. McGraw-Hill International.
- .. S Ramamruthan and R Narayan. Design of Reinforced Concrete Structures. Dhanpat Rai & Sons, Delhi.
- .. SK Mallick and A P Gupta. Reinforced Concrete. Oxford & IBH Publishing (P) Ltd., New Delhi.

CV 411

ADVANCED STRUCTURAL ANALYSIS

Group A

Matrix analysis, displacement and force methods: Computers and structural analysis; brief discussion on analysis procedures with introduction to displacement and force methods; basic structural system and mathematical model; coordinate systems, joint displacement and joint loads; statically determinate and indeterminate structures; kinematically determinate and indeterminate structures.

Member end load matrix; Member deformation matrix; influence coefficients; global flexibility matrix; global stiffness

matrix; local member flexibility and stiffness matrices; plane frame members; space frame members.

Flexibility analysis of statically determinate structures; computer program for flexibility analysis; flexibility analysis of statically indeterminate structures; computer program for flexibility analysis for statically indeterminate structures.

Stiffness analysis method; computer program for stiffness analysis of kinematically determinate systems; stiffness analysis of kinematically determinate plane frame; stiffness analysis of kinematically indeterminate systems; assembly process for obtaining global stiffness matrix from member stiffness matrices for plane truss, space truss, plane frame and space frame.

Group B

Stress analysis and failure criteria. Analysis of stress and strain—principal stresses and strains, deviatoric stress and strain, stress and strain invariants; compatibility conditions; and equilibrium equations. Failure criteria stress-strain relations for anisotropic and isotropic elastic materials; yield (failure) criteria

Stress concentration. Fatigue failure.

Plates and shells; thin plate bending theory, thin plate bending solutions; membrane theory of shells; bending theory—circular cylindrical shells.

Recommended Books

- .. J F Fleming. Computer Analysis of Structural Systems. McGraw Hill International.
- .. SP Timoshenko and JN Goodier. Theory of Elasticity. McGraw Hill International.
- .. R Agor. Structural Analysis. (Second Edition) Khanna Publishing, New Delhi.
- .. D S Bedi. Strength of Materials. Khanna Publishing Co. (P) Ltd., New Delhi.

CV 412

DESIGN OF RCC AND PRESTRESSED CONCRETE STRUCTURES

Group A

Introduction to working stress and limit states/ design. Working stress design of rectangular beams.

Working stress design of T-beams. Design of tension members and compression members.

Limit states, design of beams.

Design of two-way slabs, design of circular slabs, and design of flat slabs.

Design of miscellaneous structures—staircase, curved beam, lintel, etc.

Group B

Limit state, design of columns. Design of members under combined bending and direct stresses.

Design of footings and design of bridges.

Design of liquid retaining structures.

Design of prestressed concrete structures. Design of masonry structures.

Recommended Books

- .. P Dayaratnam. Design of Reinforced Concrete Structures. Oxford and IBH Publishing Co (P) Ltd., New Delhi.
- .. K SRakshit. Design and Construction of Highway Bridges. New Central Book Agency, Kolkata.
- .. P Dayaratnam. Brick and Reinforced Brick Structures. Oxford & IBH Publishing Co (P) Ltd., New Delhi.
- .. S B Vanakudre. Prestressed Concrete Khannabooks.com. Khanna Publishing, Delhi.

CV 413

DESIGN OF STEEL STRUCTURES

Group A

Industrial buildings: Loads, classification and types of buildings, braced and unbraced buildings.

Steel towers: Transmission line towers; microwave towers; guyed towers.

Group B

Multistoried buildings: Analysis, types of loads, and design.

Other miscellaneous topics: Steel bridges; pressure vessels; water tanks, chimneys, etc.

Recommended Books

- .. P Dayaratnam. Design of Steel Structures S Chand & Co. Ltd., New Delhi.
- .. Steel Designers' Manual. ELBS Publication.

CV 414

STRUCTURAL DYNAMICS

Group A

Single degree of freedom systems: Equations of motion. Free vibrations, damping. Response to harmonic excitation. Response to general dynamic loading. Duhamel's integral. Numerical methods.

Response spectrum: Concept. Deformation, pseudovelocity and pseudo-acceleration response spectra. Analysis of SDOF systems using response spectrum. Difference between response spectrum and design spectrum.

Group B

Multi degree of freedom systems: Equations of motion. Free vibrations, natural frequencies and modes. Free vibration analysis for classically damped systems. Damped matrix. Rayleigh damping. Modal analysis. Earthquake analysis of linear systems

by response spectrum method.

Continuous systems: Equations of motion. Natural frequencies and modes. Modal orthogonality. Earthquake response spectrum analysis.

Approximate methods: Rayleigh's method. Dunkerley's method.

Recommended Books

- .. A K Chopra. Dynamics of Structures: Theory and Applications to Earthquake Engineering. Prentice Hall of India (P) Ltd., New Delhi.
- .. M Paz. Structural Dynamics: Theory and Computation. Chapman & Hall, New York.

CV 415

SEISMIC DESIGN OF STRUCTURES

Group A

Characteristics of earthquake: Earthquake terminology. Magnitude. Intensity. Measurement of ground motion. Frequency-magnitude relationship. Liquefaction.

Strong ground motion: Acceleration time histories. Peak parameters (peak ground acceleration/ velocity/ displacement). Response spectrum. Site effects.

Earthquake analysis of structures: Idealisation on structures. Response spectrum analysis. Equivalent force concepts. Torsionally coupled systems.

Group B

Concepts of earthquake-resistant design: Objectives. Ductility, ductility reduction factor, overstrength, response reduction factor. Design response spectrum. Lateral stiffness. Building configuration. Base isolation. Concept of structural control.

Building codes: Performance of buildings in past earthquakes. Historical perspective on code development. Indian code (IS 1893) provisions for buildings.

Detailing of reinforced concrete and masonry buildings: Provisions of IS 13920, IS 4326, IS 13827. Retrofitting and strengthening of buildings (IS 13935).

Other structures: Introduction to concept of seismic design for bridges and liquid retaining tanks.

Recommended Books

- .. D J Dowrick. Earthquake Resistant Design. John Wiley International, Singapore.
- .. D Key. Earthquake Design Practice for Builders. Thomas Telford, London.

CV 421

PRINCIPLES OF ENVIRONMENTAL ENGINEERING

Group A

Environmental engineering: Introduction and scope. Ecology and environment—definitions and interactions, anthropogenic effects.

Pollution and environmental quality: Air and water quality parameters, variation of water quality in the hydrogeologic cycle, beneficial uses of water, water quality criteria and standards for various beneficial uses, air quality criteria, ambient air standards.

Pollutants: Definition, significance, measurement (both air and water).

Wastes: Solid, liquid and gaseous, and their sources and characteristics.

Water and wastewater quality estimation: Population forecast, water demand for various purposes, variation in quantity of water and wastewater.

Overview and elements of water supply scheme.

Group B

Water/ wastewater quality enhancement: Unit operations and processes, physico-chemical vs. biological methods, solid-liquid separation, grit removal, screening, comminution, mixing, equalization, coagulation, flocculation, filtration, disinfection, aeration and gas transfer, precipitation, softening, adsorption and ion exchange.

Surface and groundwater treatment: Sequencing of unit operations and processes, plant layout, hydraulic considerations.

Rural water supply and sanitation.

Wastewater collection system and water distribution system: Review of analysis, design and appurtenances.

Recommended Books

- .. OP Gupta. Elements of Environmental Pollution Control. Khanna Book Publishing Company Private Limited, New Delhi.
- .. H S Peavy, D R Rowe and G Tchobanoglous. Environmental Engineering. McGraw-Hill International.

CV 422

ENVIRONMENTAL ENGINEERING—PROCESSES AND MANAGEMENT

Group A

Introduction: Review of environmental engineering.

Biological processes for water and wastewater quality enhancement. Microbiological aspects, classification of bioprocesses, aerobic and anaerobic processes, dispersed and immobilized growth systems, reactor analysis, unit operations

and processes, aerobic dispersed growth systems—activated sludge process and its modifications, aerobic immobilized growth systems—trickling filters, rotating biological contactors, anaerobic processes—conventional, stationary and mobile, fixed film, sludge blanket, ponds and lagoons, septic tanks.

Overview and elements of wastewater disposal scheme: Primary, secondary and tertiary treatment, sequencing of unit operations and processes, plant layout, hydraulic considerations.

Disposal of wastes: Liquid—inland waters, on land, ocean; disposal standards—effluent and stream, gaseous atmospheric dispersion, meteorological and stack factors, emission standards.

Group B

Air pollution control: Stack height estimation, particulate removal mechanisms and processes, reduction of gaseous pollutants—adsorption, absorption, neutralization, incineration.

Solid waste management: Collection, classification, reduction—quantity and hazard potential, composting, land filling, incineration, ground water pollution.

Noise pollution and hazardous waste management: Definition, measurement, control measures.

Environmental impact and auditing: Environmental impact and assessment—statements and methodologies, environmental laws—special constitutional provisions, role of federal and state governments and NGOs in monitoring and control of environmental pollution and resources, environmental auditing.

Recommended Books

- .. O P Gupta. Elements of Environmental Pollution Control Khanna Book Publishing Company Private Limited, New Delhi.
- .. H S Peavy, D R Rowe and G Tchobanoglous Environmental Engineering, McGraw-Hill International.

CV 423

AIR POLLUTION AND ITS CONTROL

Group A

Introduction: History of air pollution, air pollution systems, concepts of air quality, air quality criteria and standards, atmospheric chemistry and philosophy of air pollution control.

Air Pollution sources: Stationary—industrial, domestic, non-point Mobile: Petrol and diesel-driven vehicles.

Assessment of air pollution: Preparation of emission inventory, emission factors, pollution loads.

Effects of air pollution: Human health, vegetation and property.

Air quality surveillance: Design of air quality monitoring network.

Meteorology: Physics of atmosphere—sun atmosphere, heat balance, wind speed, direction, ventilation, mixing height, stability, class.

Group B

Transport and dispersion of pollutants: Turbulence, advection, diffusion equation, Gaussian model and its variation, plume rise, fate process and migration pathways, dry and wet deposition.

Engineering control: Setting chambers, inertial devices, bag filters, dry and wet scrubbers, mobile source control, two- and three-way catalytic converters.

Source sampling and monitoring: Isokinetic sampling. Air pollution legislations, international treaties, emission standards. Global and regional air pollution issues.

Recommended Books

- .. K Wak and C F Warner. Air Pollution: Its Origin and Control. Harper & Row, New York.
- .. M N Rao and H V N Rao. Air Pollution. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. O P Gupta. Elements of Environmental Pollution Control Khanna Publishing, Delhi.

CV 424

DESIGN OF WATER AND WASTEWATER TREATMENT SYSTEMS

Group A

Environmental engineering: Introduction and scope. Design consideration.

Environment quality and pollution: Water quality and its parameters; variation of water quality in hydrogeologic cycle, beneficial uses of water, water quality criteria and ambient water standards.

Water quality and health.

Consideration in water supply scheme.

Water and wastewater quantity estimation: Population forecast; water demand for various purposes, variation in quantity of water and wastewater.

Design of grit removal, equalisation, coagulation—flocculation, filtration, disinfection; aeration and gas transfer, and distribution system.

Group B

Wastewater characterisation, wastewater quality parameters, BOD, COD, various types of solids, physicochemical, biological methods, solid-liquid separation, grit removal, screening, comminution, mixing equalization.

Design of activated sludge process, trickling filters, oxidation

ponds, oxidation ditch.

Water quality modelling: DO-BOD Streeter-Phelps equation.

Wastewater collection system: Analysis, design and appurtenances.

Recommended Books

.. O P Gupta. Elements of Environmental Pollution Control (including Air Pollution, Noise Pollution, etc) Khanna Publishing, New Delhi.

.. H S Peavy, D R Rowe and G Tchobanoglous Environmental Engineering. McGraw-Hill International.

CV 425

WASTE MANAGEMENT AND ENVIRONMENTAL IMPACT ASSESSMENT

Group A

Sources and types of wastes. Solid, liquid and gaseous wastes from various industries. Water use in industry, industrial water quality requirements.

Control and removal of specific pollutants in industrial wastewater, e.g., oil and grease, cyanide, fluoride, toxic organics, heavy metals, radioactivity, etc. Solid and hazardous wastes—definitions, concept and management aspects.

Recent trends in industrial waste management, cradle to grave concept, life cycle analysis, clean technologies. Case studies of various industries.

Environment audit, accounts audit, relevant methodologies, regulations. Introduction to ISO and ISO 14000.

Environmental management, problems and strategies. Review of political, ecological and remedial actions.

Group B

Multidisciplinary environmental strategies, the management dimensions. Environmental impact Assessment (EIA)—an overview.

Definitions and concepts of sustainable development. Initial environmental examination, environmental appraisal, environmental audit.

Environmental impact factors and areas of consideration, measurement of environment impact, scope and methodologies of EIA. Case studies stressing physical aspects of EIA.

Recommended Books

.. L W Canter. Environmental Impact Assessment. McGraw-Hill International.

.. A Dasgupta and N L Nemerow. Industrial and Hazardous Waste Treatment. van Nostrand Reinhold, New York.

.. O P Gupta. Elements of Environmental Pollution Control Khanna Publishing Co. Ltd., New Delhi.

CV 431

TRANSPORTATION ENGINEERING

Group A

Components of transportation.

Vehicle and driver characteristics

Resistance to vehicles and power requirements; Perception-Reaction time of drivers; Visual acuity of drivers; Driver comfort.

Pavement materials; Aggregates; Bitumen; Concrete.

Pavement design; Flexible pavements; Rigid pavements.

Railway track and structures; Design of formation, sleeper density, rail joints, long welded rails; Properties of sleeper material, ballast, points and crossing, railway signalling, interlocking of signals and points.

Geometric design; Horizontal alignment; Vertical alignment; Sight distance.

Group B

Airport planning and design; Regional planning; Airport site selection; Airport capacity; Airport design; Runway orientation; Basic runway length and its corrections; Taxiway system; Aircraft parking; Terminal building

Public transportation, different alternatives and their usefulness.

Traffic flow fundamentals, traffic stream variables, relation between traffic stream variables.

Traffic studies: Traffic volume studies, speed studies, origin and destination studies, traffic flow characteristics, traffic capacity study, parking study, accident studies

Capacity and level of service analysis: Level of service analysis, capacity of various traffic facilities like highways, freeways, signalized intersections.

Recommended Books

.. L R Kadiyali. Transportation Engineering. Khanna Book Publishing, Delhi.

.. L R Kadiyali. Highway Engineering (khannabooks.com) Khanna Books, Delhi.

.. SK Khanna and M G Arora. Airport Planning and Design. Nem Chand & Bros., Roorkee.

.. A Course in Railway Engineering. Dhanpat Rai & Sons, Delhi.

CV 432

TRAFFIC AND TRANSPORTATION SYSTEMS

Group A

Traffic engineering—introduction.

Traffic Characteristics

- Road user characteristics
- Vehicular characteristics

Traffic Studies

- Use of speed, journey time, and daily studies
- Method of measuring spot speeds.
- Methods for measurement of running speed and journey speed

- Vehicle volume counts
- Origin-destination studies
- Parking studies
- Statistical analysis for traffic studies

Traffic Controls

- Traffic signs
- Traffic markings
- Traffic signals
- Design of traffic signals
- Types of traffic signals & traffic signal system

Traffic Safety

- Road accidents—causes and prevention
- Traffic management measures and their influence on accident prevention

Traffic Regulations

- Basic principles of regulations
- Regulation of speed and vehicles
- General rules concerning traffic
- Parking regulations
- Enforcement of regulations.

Group B

Urban Transportation: Introduction

- Objectives and policies
- Urban transport problems
- Urban transport systems in India
- Issues (safety, congestion, pollution, land-use policy)
- Urban transport planning process

Travel Demand Forecasting Models

- Trip generation
- Trip distribution
- Traffic assignment
- Model

Land Use and Transport Planning

- Land use transport models
- Land use as an instrument of diffusing congestion
- Hierarchy of planning

Public Transport—Needs, modes and systems

- Model split and trip characteristics
- Road based systems
- Rail based systems
- Innovative transit systems
- Automation technology
- Intelligent vehicle highway systems (IVHS)
- Bus and railway stations

Economic Evaluation of Transportation Plans

- Costs and benefits of transport project
- Time horizon in economic evaluation
- Basic principles in economic evaluation

Methods of economic evaluation.

Recommended Books

- .. L R Kadiyali. Transportation Engineering. Khanna books.com., Delhi.
- .. M K Agarwal. Urban Transportation in India. Allied Publishers Limited, New Delhi.

CV 433

TOWN PLANNING AND URBAN DEVELOPMENT

Group A

Planning thoughts through ages—early settlements—Roman, Greek, Medieval, Renaissance and industrial towns—urbanisation and settlement structure.

Garden City concept of E Howard, Geddesian trend and valley section green belts. Planning of new towns, evolution of planning concepts in India. Levels of planning surveys for urban and regional planning. Contents of master plan, regional plan, structure plan, detailed development plan. Basic principles in planning different land uses.

Group B

Planning, legislation and administration, review of planning legislation and Acts relating to urban and regional planning. Building by-laws, planning agencies and their functions. Fiscal policies and resource management in the context of urban development. 73rd and 74th CAA and its implication to planning.

Slum clearance, urban renewal, conservation, rehabilitation and redevelopment. Decentralisation policies. Review of various urban development schemes and projects.

Recommended Books

- .. Global Review of Human Settlements. Pergamon Press, London.
- .. A Kohun. History Builds the Towns. Lund Humphries, London.
- .. Bolayeli. Concepts and Techniques in Urban Analysis. Croom Helm, London.

- .. A D Thomas. Housing and Urban Renewal. George Allen and Unwin, Sydney.
- .. N Bevas and Rakoic (eds). Managing Fast Growing Cities—New Approaches to Urban Planning and Management in the Developing World. Longman, London.
- .. A K Jain. Town Planning. Khanna Book Publishing Co. Ltd., Delhi
- .. UDPFI—Guidelines—Vols 1-2 of Institute of Town Planners, New Delhi
- .. Town and Country Planning Acts of various State Governments.

CV 434

DESIGN OF WATER AND WASTEWATER TREATMENT SYSTEMS

(See page 26, subject CV 424)

CV 435

CONSTRUCTION MANAGEMENT SYSTEMS

Group A

Introduction to construction management. Construction industry and its practices. Problems of construction industry. Management problems in construction. Methodology of system design and techniques in construction. Elements of engineering economics. Probability and statistics. Allocation models, coordination and inventory model. Queuing model. Uncertainty principles. Simulation.

Engineering economics in construction management. Time value of money, interest tables and rates of payment and return. Depreciation of capital assets. Evaluation of feasibility. Public project analysis and evaluation. Case study modules.

Use of elementary statistics and probability theory. Statistical approach, probability distributions, expected value analysis, parameter estimation, statistical inference, quality control using statistical tools, regression and correlation analysis. Case study modules.

Allocation models in construction. Transportation model and its solution. Assignment model. Sequencing. Case study modules.

Group B

CPM and PERT network in construction. Applications in the field of construction, planning of scheduling phase and control phase, optimisation studies, case study modules.

Inventory management. Inventory costs, lead and economic order quantity, inventory models, ABC analysis, inventory management.

Queuing models and applications in construction technology. Queues and queuing theory, models of queues, case study modules.

Construction projects management. Organisational aspects of sectors such as housing, institutional and commercial, industrial and heavy engineering. Contracts—theory and practice. Human resources development and construction industry.

Recommended Books

- .. Mahesh Verma. Construction Planning and Management through System Techniques. Metropolitan Book Co., New Delhi.
- .. E L Grant. Principles of Engineering Economy. The Ronald Press, New York.
- .. R Levin and C Kirpatrick. Planning and Control with PERT/CPM. McGraw-Hill International.
- .. L S Srinath. PERT and CPM—Principles and Applications. Affiliated East-West Press (P) Ltd., New Delhi.

The Computerised Leap— Preparation for the Third Wave

Though 'Abacus', the first mathematical device used to facilitate arithmetical computation, was invented by the ancient Chinese before the birth of Christ, the first mechanical 'Computer' called 'Analytical Engine' was designed by Charles Babbage between 1830 and 1850. This first mechanical computer was capable of performing basic arithmetical functions.

The first commercial computer, called UNIVAC (Universal Automatic Computer), using vacuum tube circuits, was used by the US Census Bureau in 1951. Computers using such circuits belonged to the first generation. Invention of the transistor by Bell Laboratories in the USA gave birth to the second generation computers like IBM 1401 which used transistors instead of vacuum tubes. Third generation computers were introduced in the mid-1960s with the invention of tiny integrated circuits on silicon chips. Integrated chips (IC) became available in 1969. Computers using large scale integrated chips are generally called fourth generation computers.

The Micromisation

Invention of the microprocessor in 1972 has changed the computing scene dramatically. A microprocessor, when interfaced with memory and input/output units, becomes a microcomputer.

A Personal Computer (PC) is a microcomputer which has its entire central processing unit on a single microprocessor chip. A PC usually comes with a standard keyboard, a visual display unit and a dot matrix printer.

The Youngest in Service of the Elders — Computer Aided Engineering

The use of computer-based tools to help solve engineering problems can be considered as a set of four interrelated problem solving aids: computer databases and communications; computer graphics and modelling;

Computer engineering is woven around the device capable of accepting information, applying prescribed processes to the information, and supplying the results of these processes. To enable doing this, the device has some basic hardware organisation, namely, input and output devices, storage, arithmetic and logic units and control unit. The root however lies in the proper understanding of the designing, manufacturing, testing and implementing them in SSI to VLSI chips for specific functions on the one hand and understanding on the other hand the aspects like information science and information technology, organisation and management of the total system. The hardware and software aspects are judiciously coordinated. Computer software consists of system software and application software. The former is designed as a set of instructions to the machine hardware to interpret and execute the latter, which in turn is a set of programming instructions for specific applications. Computer engineering is highly flexible in communication with the user in different compatible languages. The engineering has touched altogether a new dimension with the advent of "artificial intelligence" requiring a blending of high level mathematics, physics, cybernetics and multidisciplinary engineering.

computer simulations and analyses; and data acquisition and control of physical prototypes and production processes. The applications of computer-aided engineering extends right from design stage in CAD to offer flexibility in manufacturing through computer-aided manufacturing (CAM) and ultimately to close down with inspection in computer integrated manufacturing (CIM).

Modelling the Real

Engineers are trained to model real world system with more or less analogous equations. This simulation is done by building a mathematical

prototype, which is faster, cheaper and more flexible than building and testing the real thing. An added advantage of mathematical simulation is that it allows a better understanding of the system under investigation. Furthermore, variations may be tried to get an optimal solution. Finite element analysis techniques are excellent examples of the analytical applications of computer-aided engineering. The technique can be applied to any field problem, such as heat transfer, electrodynamics and behaviour of structures.

Achievements in India

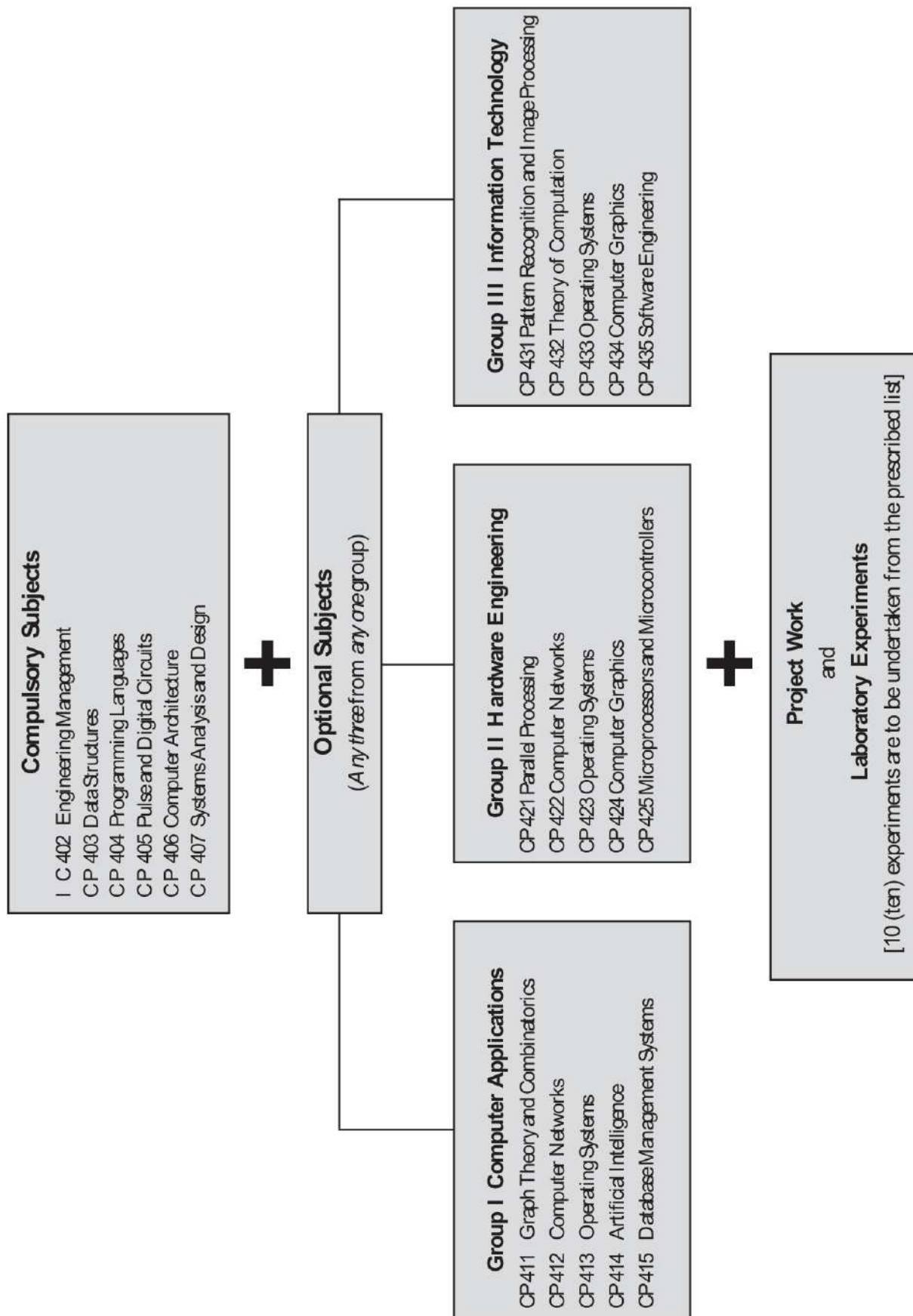
Realising the importance of the computer industry in the national development programme, the Government of India in 1984 announced a rationalised computer policy with the main objectives of : (i) enabling manufacture of computers based on the latest technology and progressively increasing indigenisation, consistent with economic viability, (ii) simplifying existing procedures to enable users to obtain computers meeting their requirements, and (iii) promoting appropriate applications of computers, which catalyse the development process.

In pursuance of these objectives, the Department of Electronics had launched a pilot project 'Computer Literacy and Studies in Schools (CLASS)'. Also, 42 Resource Centres were established to provide technical and other backup services to schools including training of teachers and monitoring of the programme.



Computer Screen

COMPUTER SCIENCE AND ENGINEERING



COMPUTER SCIENCE AND ENGINEERING

IC 402

ENGINEERING MANAGEMENT

(See page 13, subject IC 402)

CP 403

DATA STRUCTURES

Group A

Time and space analysis of algorithms. Order notation.

Linear data structures: Sequential representations: Arrays and lists, stacks, queues and dequeues, strings and their applications.

Linked representations: Linear linked list, circular linked list, doubly linked list and their applications.

Recursion: Design of recursive algorithms. Tail recursion, when not to use recursion, removal of recursion.

Group B

Nonlinear data structures: Trees, binary trees, traversals and threads, binary search trees, insertion and deletion algorithms, height-balanced and weight-balanced trees, B-trees, B+ trees, application of trees.

Graph representation. Breadth first search, depth first search. Hashing, hashing functions, collision resolving techniques. Sorting and searching algorithms, bubble sort, selection sort, insertion sort, quick sort, merge sort, heapsort, radix sort.

File structures: Sequential and direct access, relative files, indexed files—B+ tree as index, multi-indexed files, inverted files, hashed files.

Recommended Books

- .. R S Salaria. *Data Structures*. Khanna Book Publishing Co. (P) Ltd., New Delhi.
- .. A Aho, J Hopcroft and J Ullman. *Data Structures and Algorithms*. Addison-Wesley Publishing Co., New York.
- .. D E Knuth. *The Art of Computer Programming-Vol. I*. Narosa Publishing House, New Delhi.

CP 404

PROGRAMMING LANGUAGES

Group A

Principles of high-level language programming, file structure and file handling, block structured languages, design principles, abstractions, control and data structures, binding, parameter passing mechanism.

LISP: Overview of LISP, functions, conditions, arithmetic, recursion, iteration, application of LISP in artificial intelligence problems.

C language: Fundamentals of C, types, operators and expressions, control flow, C-functions, recursion, pointers and arrays, structures, common line arguments, unions, Bitwise operators, file handling in C.

Group B

C++: Overview of C++, class and objects, arrays of objects, operator overloading, concepts of inheritance, base class, derived class, multilevel inheritance, nesting of classes, file concepts, library functions, streams, templates.

Java: Features of Java, Java arrays, two-dimensional array, multidimensional arrays, Java files, file I/O and streams, event-driven programming, events and applets, passing parameters to Applets. Examples.

Recommended Books

- .. T W Pratt and Zelkowitz. *Programming Languages: Design and Implementation*. Prentice Hall of India (P) Ltd., New Delhi.
- .. R S Salaria. *Application Programming in C*. Khanna Book Publishing Co. (P) Ltd., New Delhi.
- .. A Narayan and N E Sharkey. *An Introduction to LISP*. Affiliated East-West Press (P) Ltd., New Delhi.
- .. E Balaguruswamy. *Programming with JAVA*. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. RS Salaria. *Object Oriented Programming With C++*. Khanna Book Publishing Company Private Limited, New Delhi.

CP 405

PULSE AND DIGITAL CIRCUITS

Group A

Combinational Logic

Boolean algebra: Introduction, postulates of Boolean algebra, fundamental theorems, uniqueness properties, laws of Boolean algebra, De Morgan's theorem, the (inclusion) implication relation, bounds of Boolean algebra, duality in Boolean algebra, Boolean constants, variables and functions, two-valued Boolean algebra—switching algebra, electronic gates and mechanical contacts.

Boolean functions and logic operations: Introduction, the normal form, the canonical form, fundamental products and sums, disjunctive and conjunctive normal forms, binary, octal and hexadecimal, designations, self dual functions, logical operations, NAND and NOR operations, EXCLUSIVE-OR operation, functionally complete sets.

Minimization of switching functions: The Karnaugh map—introduction cubes and the Karnaugh map, prime cubes, maximum sum of products, minimum product of sums, don't care forms, five- and six-variable maps, multiple output minimization.

Tabular methods of minimization: Introduction, Quine-McCluskey algorithm, the dominance relation cyclic functions, the degree of adjacency and essential prime cubes.

Logic synthesis of switching functions: Introduction, AND, OR and inverter networks, NAND and NOR networks, EXCLUSIVE-OR networks, multiplexers, read only memories, programmable logic arrays (PLA), PLA minimization, essential prime cube theorems, PLA folding.

Reliable design and fault detection tests: Introduction, fault classes and models, fault diagnosis and testing, test generation, fault table method, path sensitization method, Boolean difference method, reliability through redundancy, hazards and hazard-free designs, quadded logic.

Group B

Sequential Circuits

Introduction to synchronous sequential circuits, the finite-state model—basic definitions, the memory elements and their excitation functions—S-R flip-flop, J-K flip-flop, D flip-flop, T flip-flop, synthesis of synchronous sequential circuits.

Capabilities, minimization and transformation of sequential machines, the finite-state model—further definitions, capabilities and limitations of finite-state machines, state equivalence and machine minimization, simplification of incompletely specified machines compatible states, the non-uniqueness of minimal machines, closed set of compatibles. The compatible graph and the merger table.

Asynchronous sequential circuits. Fundamental mode circuits, synthesis, state assignments in asynchronous sequential circuits, pulse mode circuits.

Finite state recognisers: Deterministic recognisers, transition graphs, converting non-deterministic into deterministic graphs, regular expressions, transition graphs recognising regular sets, regular sets corresponding to transition graphs.

Recommended Books

- .. N N Biswas. Logic Design Theory. Prentice-Hall of India (P) Ltd., New Delhi.
- .. AK Maini. Electronics Simplified (Edition 2017) Khanna Book Publishing, New Delhi.

CP 406

COMPUTER ARCHITECTURE

Group A

Introduction to basic structure and operational concepts, instruction formats, instruction execution

process, addressing modes, stacks and subroutine handling, instruction sets and organisational features of some representative machines.

Control unit: Hardware control unit design, microprogramming and microprogrammed control unit design, microsequencer and bit sliced microprocessor (AMD 2900) based microprogram control unit design, horizontal and vertical microprogramming, nanoprogramming, emulation.

Main memory organisation: Memory hierarchy, virtual memory, cache memory, interleaved memory and linear addressing techniques.

I/O organisation: Addressing of I/O devices, memory mapped I/O and I/O mapped I/O, data transfer techniques—programmed, interrupt driven, DMA, I/O channels programming, data transfer over synchronous and asynchronous buses, some standard interface bus like VME/ IEEE-488.

Group B

Introduction to RISC and CISC architecture and their comparison.

Pipelining: Classification, scalar and vector pipelining, instruction pipelining and execution pipelining, control strategy for pipeline scheduling and performance analysis.

Associative memory and its implementation with example algorithms to run on associative memory machines.

Flynn's classification of multiprocessor machines, SISD, SIMD, MIMD (both loosely coupled and tightly coupled).

Introduction to some interconnection network (mesh, cube, cycle, hypercubes, pyramid and omega).

Recommended Books

- .. JPH Hayes. Computer Architecture and Organisation. McGraw Hill International.
- .. M Mano. Computer Systems Architecture. Prentice Hall of India (P) Ltd., New Delhi.
- .. K Hwang and F A Briggs. Computer Architecture and Parallel Processing. McGraw Hill International.

CP 407

SYSTEMS ANALYSIS AND DESIGN

Group A

Systems Development Life Cycle, classic life cycle.

Prototyping.

Feasibility study: Cost estimation, cost-benefit analysis.

Physical and logical data flow diagrams.

Requirement analysis: Entity-relationship diagrams, decision tables, CASE tools.

Systems design: Refinement, software architecture, program design fundamentals.

Group B

Structured programming modularity—cohesion and coupling.

Design documentation.

System implementation: System simulation, planning for coding and testing, verification and validation.

Project review and walkthrough.

Input-output design, forms design, dialogue design.

File design, security and control.

Management Information System.

Recommended Books

- .. NCC: Introduction to Systems Analysis and Design. Vols. 1 and 2. Galgotia Publications (P) Ltd., New Delhi.
- .. I Hawryszkiewicz. Introduction to Systems Analysis and Design. Prentice Hall of India (P) Ltd., New Delhi.
- .. I Singh. Systems Analysis and Design. Khanna Books Publications (P) Ltd., New Delhi.

CP 411

GRAPH THEORY AND COMBINATORICS

Group A

Graphs and digraphs, subgraphs, degree, walk path, cycle, trees, spanning trees, distance, connectivity, reactivity and reachability, adjacency matrix.

Eulerian paths and circuits in graphs and digraphs.

Hamiltonian paths and circuits in graphs and tournaments.

Matching, perfect matching, 4-colour theorem, vertex colouring, chromatic polynomial edge colouring.

Group B

Planar and non-planar graphs, Euler's formula, Kuratowski's theorem. Network, Max flow-Min cut theorem. Graph enumeration—Polya's counting theorem. Graph algorithms—shortest path, minimal spanning tree, etc.

Basic combinatorial numbers, recurrence, generating functions, multinomials. Counting principles. Polya's theorem, inclusion and exclusion principles. Block design and error correcting codes. Hadamard matrix. Finite geometries.

Recommended Books

- .. N Deo. Graph Theory with Applications to Engineering and Computer Science. Prentice-Hall of India (P) Ltd., New Delhi.
- .. JA Bandy and U SR Murty. Graph Theory with Applications. Macmillan International.

- .. S B Singh. Combinatorics and Graph Theory. Khanna Book Publishing (P) Ltd., New Delhi.

CP 412

COMPUTER NETWORKS

Group A

Introduction: Goals and applications of networks, WAN, MAN and LAN, computer networks and distributed computers.

Network architecture: ISO/OSI model, topology, connectivity analysis, queuing theory and delay analysis.

Physical layer: Theoretical basis of data communication, modems, FDM and TDM, X21, communication satellites, message and packet switching, terminal handling polling, multiplexing and concentration, error detection and correction techniques. Hamming codes and polynomial codes.

Group B

Data link layer and network layer: Framing techniques, network protocols—stop and wait protocol and its performance, sliding window protocol.

LANs: Ethernet and token ring. CCITT recommendation of X.25.

Introduction and overview of internet, TCP/IP, internet address. Introduction to web, web design and search engine. Mapping of internet address to physical address, ARP.

Routing, flow control and congestion analysis.

Recommended Books

- .. A S Tanenbaum. Computer Networks. Prentice-Hall of India (P) Ltd., New Delhi.
- .. B Sidhu. An Integrated Approach to Computer Networks. Khanna Book Publishing. Delhi.
- .. D W Davies. Computer Networks and Their Protocols. John Wiley and Sons, New York.

CP 413

OPERATING SYSTEMS

Group A

Functions and features of OS. Different types of OS viz., single user, batch processing, multiprogramming, timesharing.

Single user system: Basic I/O system, ROM resident and disk based I/O system.

Command interpreter with reference to any available operating systems (like MSDOS).

File management and directory structures. Memory management, partitioned, paging, segmentation and thrashing. Processor management and different scheduling techniques.

Resource management, disk allocation and scheduling.
Deadlock detection, recovery, prevention and avoidance.

Group B

Concurrent processor issues—functionality, mutual exclusion, synchronization, interprocess communication.

Primitives like semaphores and their implementation using machine primitives.

Concept of conditional critical region and monitors. Interrupt handlers, device drivers and controllers, device independent I/O and piping.

Design issue of multiuser operating systems (with reference to UNIX).

Advanced concepts of program and data security and protection.

Distributed systems concepts and few basic results.

Recommended Books

- .. A Silberschatz and P B Galvin. Operating System Concepts. Addison Wesley Publishing Co., New York.
- .. A S Tanenbaum. Operating Systems: Design and Implementation. Prentice Hall of India (P) Ltd., New Delhi.
- .. Ekta Walia. Operating System Concepts. Khanna Publishing Co., New Delhi.

CP 414

ARTIFICIAL INTELLIGENCE

Group A

Introduction. Cognitive science and perception problems. Problem solving paradigm, introduction to search techniques, problem representations through heuristics, search spaces and/or graphs.

Basic heuristic search procedures, specialized search techniques, decomposable search strategies.

Knowledge representation through propositional and predicate logic, fuzzy logic and some applications. Solutions of artificial intelligence problems by PROLOG.

Group B

Rule based deduction and expert systems with an example of MYCIN.

Knowledge engineering, inference engines and expert system shells.

Computer vision and natural language processing.

Concept of neural network.

Recommended Books

- .. E Charniak and D McDermott. Introduction to Artificial Intelligence. Addison Wesley Publishing Co., New York.

- .. Rich. Artificial Intelligence. McGraw-Hill International.
- .. Munish C Trivedi. Artificial Intelligence. Khanna Publications (P) Ltd., New Delhi.

CP 415

DATABASE MANAGEMENT SYSTEMS

Group A

Introduction. Database concepts, architecture, physical data organization, entity relationship, data models—network, hierarchical and relational.

Relational model. Storage organization, relational algebra, relational calculus, query languages, functional dependencies, decomposition of relational schemes, query optimisation.

Group B

Database Management System (DBMS): Typical DBMS based on relational model, DDL, creating, editing, searching, sorting, relational operations, formatted report, etc.

Features of a commercially available RDBMS as case study (ORACLE).

Data administration. Processing system life cycle, security and integrity, office automation system.

Recommended Books

- .. C J Date. An Introduction to Database Systems—Vol. I & II. Addison Wesley International.
- .. R P Mahapatra. Database Management System. Khanna Book Publishing, New Delhi.

CP 421

PARALLEL PROCESSING

Group A

Introducing to parallel processing, architectural classification and techniques.

Arithmetic and instruction pipelines, pipelining hazards and scheduling theory.

Super scalar architectures, asynchronous pipelines.

Interconnection networks—Hyper cubes, shuffle exchange, Tree, Mesh and Butterfly networks.

Group B

Parallel algorithm for linear algebra, sorting, Fourier transform, systolic arrays, etc.

Vector processors, shared memory multiprocessor systems.

Data flow architectures—merits and demerits.

Operating systems for parallel processors.

Some case studies, namely, IBM 370, Cray X-MP, Cray 1, Cray 2, Cyber 205.

Recommended Books

- .. K Hwang and F A Briggs. Computer Architecture and Parallel Processing. McGraw-Hill International.
- .. J Robert Baron and Higbie Lee. Computer Architecture. Galgotia Publications (P) Ltd., New Delhi.
- .. Virendra Kumar. Parallel Algorithms & Computation. Khanna Publishing Co. (P) Ltd., New Delhi.
- .. SLakshmivarahan and SK Dhall. Analysis and Design of Parallel Algorithms. McGraw-Hill International.

CP 422

COMPUTER NETWORKS

(See page 34, subject CP 412)

CP 423

OPERATING SYSTEMS

(See page 34, subject CP 413)

CP 424

COMPUTER GRAPHICS

Group A

Various graphic display devices and interactive devices.

Line and curved drawing algorithms.

Area filling—Scan line algorithm, seed fill algorithm, half toning.

Two-dimensional transformation—translation, scaling, rotation.

Group B

Windowing and clipping techniques.

Three-dimensional graphics and transformations, reflections and viewing projections.

Hidden line and hidden surfaces removal algorithms.

Animation techniques.

Recommended Books

- .. S Harrington. Computer Graphics: A Programming Approach. McGraw-Hill International.
- .. W M Newman and Robert F Sproull. Principles of Interactive Computer Graphics. McGraw-Hill International.
- .. Gautam Roy. Computer Graphics. Khanna Publishing Co. (P) Ltd, New Delhi.

CP 425

MICROPROCESSORS AND MICROCONTROLLERS

Group A

Microprocessor architecture and microcomputer systems, memory systems, input and output devices. Number systems—binary, hexadecimal and BCD numbers, 2s complement and arithmetic operations.

8085 microprocessor architecture. Memory interfacing address decoding techniques, memory read and write operations. Memory map. Interfacing I/O devices—Memory-mapped I/O and I/O mapped I/O. Polled and interrupt modes of data transfer. 8085 interrupts, direct memory access. Introduction to 16-bit microprocessor using 8086 as an example. Concept of debugger and MASM/TASM for PC assembly language programming.

Peripheral devices. 8255 programmable peripheral interface, 8253 programmable counter timer, serial communication with SID and SOD, 8251 programmable communication interface, 8259 programmable interrupt controller, keyboard and display devices.

8085 assembly language programming: 8085 instructions—addressing modes. Stack and subroutines. 8085 programmer's model—CPU registers. Addition, subtraction and multiplication routines. Software delay and counting routines. Logical operations. Analog and digital I/O interface routines—ADC and DAC.

Software development systems: Assemblers and cross assemblers. Microprocessor applications. Microprocessor based system design aids and trouble-shooting techniques.

Group B

Introduction to microcontroller: Comparison of various microcontrollers. 8051 microcontroller architecture. Bi-directional data ports, internal ROM and RAM, counters/timers. Oscillator and clock.

8051 registers. Memory organisations—program memory and data memory, internal RAM and bit addressable memory, special functions, registers, memory map.

External memory systems and I/O interface. Accessing external program memory, accessing external data memory, available I/O ports during external memory access. Alternate port functions. Serial interface. 8051 interrupts. Power down modes.

8051 assembly language programming. 8051 instruction sets, addressing modes, bit level operations. Arithmetic routines, counting and timing under interrupt control, keyboard and display interface routines, accessing lookup tables.

Software development systems. Assemblers and simulators. Microcontroller based system design and applications.

Recommended Books

- .. R S Gaonkar. Microprocessor Architecture: Programming and Applications with 8085. Penram International Publishing (India), Mumbai.
- .. K J Ayala. The 8051 Microcontroller, Architecture, Programming and Applications. Penram International Publishing (India), Mumbai.
- .. Tu-Cheng Liu and G A Gibson. Microcomputer Systems: The 8086/ 8088 Family, Architecture, Programming and Design. Prentice-Hall of India(P) Ltd., New Delhi.
- .. A K Gautam. Advance Microprocessor Khanna Publishing Co. Ltd., New Delhi.

CP 431

PATTERN RECOGNITION AND IMAGE PROCESSING

Group A

Hyperplane properties and decision functions. Minimum distance pattern classification with simple and multiple prototypes.

Clustering: K means and isodata algorithm, pattern classification by likelihood functions, bayes classifier, learning and estimation of mean vector and covariance matrix.

Trainable pattern classifier—Gradient technique, Robbins-Monre algorithm, potential functions and least mean square errors.

Feature selection by entropy minimization, Karhuner-Luke expansion and divergence maximization.

Group B

Image representation, digitization, quantization, compression and coding.

Transform for image processing, restoration, enhancement, segmentation, thinning

Description of line and shape, statistical and syntactic models of image classification.

Morphological methods of image analysis.

Recommended Books

- .. R O Duda and P E Hart. Pattern Classification and Scene Analysis. John Wiley & Sons, New York.
- .. J T Tou and R C Gonzales. Pattern Recognition Principles. Addison-Wesley Publishing Co., New York.
- .. A Rosenfield and A C Kak. Digital Picture Processing: Vol I & II. Academic Press.
- .. Ik vinderpal Singh. Digital Image Processing. Khanna Publishing Co., New Delhi.

CP 432

THEORY OF COMPUTATION

Group A

Regular sets and regular expression, deterministic and non-deterministic and finite automata, equivalent finite automation of both. Minimization of states for deterministic finite automata.

Chomsky hierarchy of grammars, equivalent context free grammars.

Chomsky normal form, recursiveness of context sensitive grammar, syntax-directed translations.

Pushdown automata, pumping lemma for context-free languages, automata for syntax-directed translations.

Group B

Turing machines and its variants, universal turing machines, recursive functions and sets. Equivalence of recursive functions and computable functions.

Complexity theory. Space complexity, time complexity, simulation of RAM by TM and its complexity, NP-completeness concepts and some standard NP complete problems.

Recommended Books

- .. J E Hopcroft and J D Ullman. Introduction to Automata Theory, Languages and Computation. Addison-Wesley Publishing Co., New York.
- .. R B Patel. Theory of Computation. Khanna Books Publishing, New Delhi.
- .. J G Borrokshear. Theory of Computation, Formal Languages, Automata and Complexity. Addison-Wesley Publishing Co., New York.

CP 433

OPERATING SYSTEMS

(See page 34, subject CP 413)

CP 434

COMPUTER GRAPHICS

(See page 36, subject CP 424)

CP 435

SOFTWARE ENGINEERING

Group A

Software project planning and management: Basic concepts of life cycles models, milestone, cost models, successive versions

model, project structure, team structure. Empirical and heuristic estimation techniques.

Requirement analysis: Specifications, algebraic axioms, regular expressions, decision tables, event tables, transition tables, FS mechanism, petri nets.

Software design: Architectural and detailed design, abstraction, information hiding, modularity, concurrency, etc, coupling and cohesion, data flow diagrams, structure charts, pseudo code, stepwise refinement, top-down and bottom-up programming.

Test plan and implementation issues—structured coding, recursion, documentation.

Group B

Modern programming language features: Typeless, strong type and pseudo strong type checking, user defined data types, data encapsulation, generic facilities, concurrency mechanism, object oriented concepts.

Program verification and validation. Unit testing, integration testing, acceptance testing, formal verification.

Software maintenance: Source code metrics, Halstead's effort equation, cyclomatic metric.

Reliability and software quality assurance.

Software cost estimation.

Recommended Books

- .. R P Mahapatra. Software Engineering. khannabooks.com.
- .. N S Gill. Software Engineering, Khanna Book Publishing Company, New Delhi
- .. Rajib Mall. Fundamentals of Software Engineering, Prentice-Hall of India (P) Ltd., New Delhi.
- .. Ian Somerville. Software Engineering. Addison-Wesley Publishing Co., New York.

Discoveries that Accelerated the Life

Long ago, a dark metallic ore having directive properties was used by navigators and called the lodestone. It was a natural magnet. Electrification of amber by rubbing with wool or fur was first discovered by Thales of Miletus as early as in 600 BC.

In 1600, in course of experiments with navigation and nautical instruments W Gilbert (1540-1603) desired to explore the behaviour of static electricity. Even the discovery of Benjamin Franklin in 1750 that lightning was electrical in nature could not contribute significantly towards the application of electricity.

In 1800, W Nicholson and A Carlisle discovered electrochemical deposition and Volta invented the electric storage cell. Invention of a practical electromagnet was announced in 1827 by Joseph Henry.

Cutting Short the Distance

Developments by Samuel Morse in electrical communication and telegraph resulted in mass production of electrical equipment. The principles of electromagnetic induction

enunciated by Michael Faraday in 1831 laid the foundation stone of electrical industry. Invention of telephone in 1876 by Graham Bell helped to further it. The invention of the carbon filament lamp by A N Lodygin in 1871 and its development by Thomas Edison in 1880 were other important milestones in electrical engineering.

The Easy-flow Power

The transformer invented by L Gaulard and J D Gibba in 1883 revolutionised the system of power transmission. N Tesla in 1888 obtained a patent of the polyphase ac induction motor which came to supply large amount of power. Sprague developed a motor for electric traction in 1887.

Developments in electrical engineering, the invention of diode and

studies on the Edison Effect by Lee De Forest opened the doors of a new discipline electronics.

The Indian Scene

Development of electricity was initiated in India as early as in 1900 with the commissioning of a hydroelectric power station at Shivsamudram in Karnataka. Coal based thermal plants account for about 60% of electric generation. The Electricity Supply Act of 1940 forms the basis of the administrative structure for electricity supply system in the country. Nuclear power generation started in 1969 at Tarapore. Possibilities of tidal power at Gulf of Cambay, Gulf of Kutch, and the estuary of the Hooghly are being explored. Similarly, exploratory work on the use of geothermal energy is being carried out in Puga Valley and Chumattang in Ladakh. Wind and other energy sources are also receiving increasing attention for commercial application.

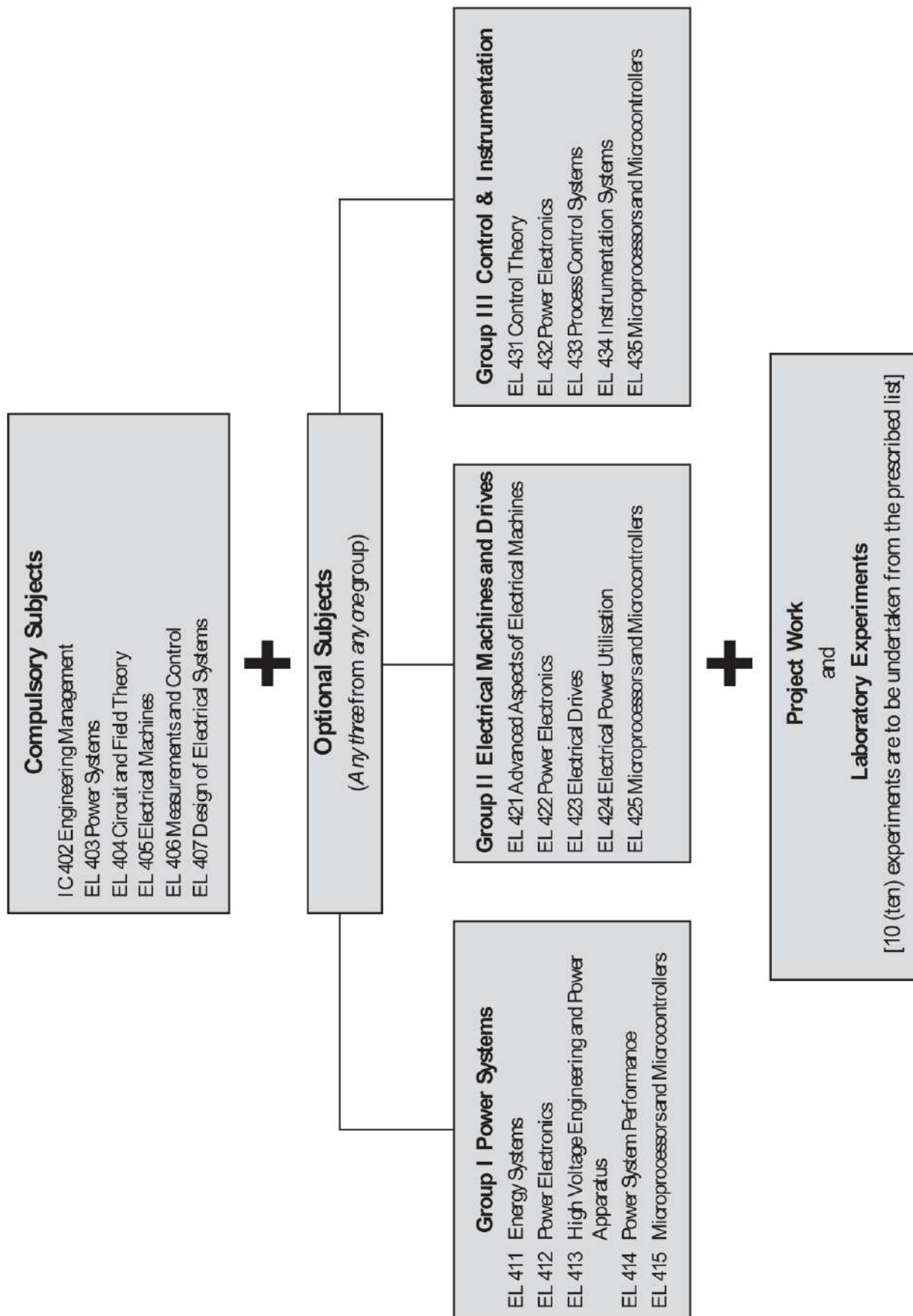
Electrical engineering deals primarily with electricity and magnetism and is devoted to the utilization of the forces of nature and materials for the benefit of mankind. It encompasses many aspects of other engineering science, mathematics and the physical sciences. It includes research, invention, development, design application and education. Harnessing the vast sources of energy and transforming them to the most convenient form, that is, electrical for the overall benefit of the society for sustenance is the prime objective.

Electrical engineers lend their expertise to other engineering fields as well. There is hardly a field of technology to which electrical engineering has not made a contribution.



A Modern Power Plant

ELECTRICAL ENGINEERING



ELECTRICAL ENGINEERING

IC 402

ENGINEERING MANAGEMENT

(See page 13, subject IC 402)

EL 403

POWER SYSTEMS

Group A

Generation of electrical power: Conventional and nonconventional methods. Typical layout of thermal and hydro power stations—main and auxiliary equipment.

Load management: Base and peak loads. Load curves. Definitions of load factor, diversity factor, demand factor. Capacity planning. Load forecasting. Capital and running costs for different types of plants. Different electricity tariffs—flat rate, two part and TOD tariff.

Generator excitation systems: Speed and excitation control of generators. Load sharing of generators in a system.

Stability of power system: Definitions of transient and steady state stability. Swing equation and its solution by step-by-step method. Equal area criterion for transient stability.

Group B

Transmission of electrical power: Overhead and underground transmission line configurations. Materials for transmission line conductors and insulators. Power station and sub-station switchyard and layouts. ACSR conductors, bundled conductors. Overhead line poles, towers and cross arms. Single and double circuit lines. Untransposed and transposed 3-phase transmission lines. Overhead line sag calculation. Effect of wind pressure and ice loading on transmission lines.

Transmission line parameters: Resistance, inductance and capacitance calculations. Skin and proximity effects. Corona and radio interference of EHV lines. Voltage distribution in suspension insulators. String efficiency. Different types of cables. Capacitance of cables. Intersheath grading.

Performance of short transmission lines: Line loss, efficiency and regulation of line. Zero regulation condition of power transmission.

Performance of medium transmission lines: Nominal T and π representation. Regulation and efficiency of medium lines.

Performance of long transmission lines: Equivalent T and π representations. Propagation constant and characteristic impedance of a long line. Ferranti effect. Surge impedance loading. Infinite line. Wavelength of line. Determination of A, B, C, D constants of transmission lines.

Transmission line charts: Power factor and power angle of a transmission line. Power angle diagram of an interconnector. Use of shunt and series capacitor in a transmission line.

Recommended Books

- .. I J Nagrath and D P Kothari. Modern Power System Analysis Tata McGraw Hill Publishing Co. Ltd, New Delhi.
- .. B R Gupta. Power System Analysis and Design. S Chand & Co. Ltd., New Delhi.
- .. A Ambikapathy. Power System Analysis, Khanna Publishing Co. (P) Ltd., New Delhi

EL 404

CIRCUIT AND FIELD THEORY

Group A

Circuit Theory

Graph of a network. Concept of tree, loop current and node pair voltage. Tie set and tie set matrices—cut set and cut set matrices. Solution of equilibrium equations on loop and node basis. Application of Laplace transforms for solving transient equations of electrical circuits. Initial and final value theorems. Unit step, impulse and ramp inputs. Laplace transform for shifted and singular functions. The convolution integral. Fourier series and its applications. Exponential form of the Fourier series. Relation between frequency spectra and Laplace transform of the Fourier series. The concept of complex frequency, transform impedance and admittance; series and parallel combinations.

Network theorems: Thevenin, Norton, Reciprocity, Superposition and Tellegen. Terminals and ports. Driving point and transfer impedances. S-plane representation: Poles and zeros. Time domain behaviour from pole and zero plots. Procedure for finding network functions for general two-port network. Radian frequency and sinusoidal network functions in terms of poles and zeros. Resonance, Q-factor and bandwidth. Asymptotic change of magnitude with frequency in terms of poles and zeros. The symmetrical lattice.

Group B

Field Theory

Vectors and vector calculus. Gradient, divergence and curl of a vector. Gauss, Stokes and Helmholtz theorems.

Electrostatics: Potential and electric field intensity. Conducting boundaries, Coaxial spheres and cylinders. Laplace's and Poisson's equations. Electrostatic energy. Uniqueness theorem. Method of images; dipoles. Dielectric polarisation, electric flux

density, permittivity. Boundary conditions. Stationary currents. Ohm's law; E.M.F. conservation of charge. Resistance of arbitrary shaped conductors. Boundary conditions and refraction of current flow lines. Numerical solutions of Laplace's equation by the method of iterations.

Magnetostatics: Magnetic field intensity and flux density. Vector potential. Magnetic dipole. Divergence of B. Ampere's law of force. Ampere's circuital law. Differential equation for vector potential. Magnetic polarisation and permeability. Boundary conditions for B and H.

Time varying fields: Faraday's law. Dynamically and statically induced E.M.F's. Inductance and stored energy. Hysteresis loss, Maxwell's equations. Displacement current. Deviation of generalised wave equations from Maxwell's equations for the magnetic vector potential. Specialization to Eddy current or diffusion equations and non-dissipative wave equations.

Plane wave propagation and eddy current phenomenon as solutions of the above relevant equations. Reflection and refraction of plane waves at the plane boundary of electromagnetic media.

Recommended Books

- .. M E Van Valkenburg. Network Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.
- .. W H Hayt. Engineering Electromagnetics. Tata McGraw Hill Publishing Co. Ltd., New Delhi.
- .. Ashfaq Husain. Network and Systems. Khanna Books, Delhi.

EL 405

ELECTRICAL MACHINES

Group A

D.C. machines: Parallel operations of D.C. generators. Speed control of D.C. motors. Testing of D.C. motors.

Transformers: Construction of 3-phase transformers. Vector groupings. Connections of 3-phase transformers—Star, delta, zig-zag, Scott and Vee connections. Grounding transformers. On load tap changing arrangement of transformers.

Synchronous machines: Regulation of synchronous generators. Salient pole synchronous machines. Direct and quadrature axis reactances. Synchronisation of 3-phase generators.

Starting of synchronous motors. V-curves for synchronous motors. Synchronous condensers. Load and torque angles of synchronous machines.

Group B

Three-phase induction motors: Torque-slip characteristics.

Starting maximum and pull out torques. Circle diagram of induction motors. Starters for induction motor. Speed control of induction motor. Testing of induction motor.

Single-phase A.C. motors: Working principle and performance of split phase shaded pole and capacitor motors. Series motor, repulsion motor.

Servo motors: D.C. and A.C.

Recommended Books

- .. P S Bimbhra. Electrical Machines. Khanna books.com.
- .. M G Say. Performance and Design of A. C. Machines. ELBS edition. Sir Isaac Pitman and Sons.

EL 406

MEASUREMENTS AND CONTROL

Group A

Measurements

Units and standards. Measurement of electrical quantities such as voltage, current and power and power factor at various frequencies.

High and low value resistance measurement. A.C. potentiometer. A.C. bridges: Owen, Anderson and Schering. Magnetic measurements: Flux, permeability and B H loop.

High voltage measurements: D.C, A.C. and impulse. Frequency and time interval measurement.

Group B

Control

Open loop and closed loop control systems. Concept of linear and nonlinear systems. Transfer functions and block diagrams. Signal flow graph.

State variables: State equations. Matrix representation of state equations. Relationship between state equations and transfer functions.

Time response: Transient analysis of feedback systems—First and second order systems. Steady state error and error coefficients.

Frequency response: Polar plots, Bode plots, logarithmic vs. phase plots.

Stability: Concept and determination of absolute stability. Routh's criterion. Nyquist criterion. Relative stability. Determination of gain and phase margin from Nyquist and Bode plots.

Root locus: Definitions. Construction of root loci. Root contours, S plane analysis of systems.

Control system components: D.C. and A.C. tachogenerators, synchros, D.C. and A.C. preamplifiers. Servo potentiometers and gyroscopes.

Recommended Books

- .. E W Golding and F C Widdis. Electrical Measurements and Measuring Instruments. S Chand & Co. Ltd., New Delhi.
- .. A Ambikapathy . Electrical Machines & Automatic Control Systems. Khanna Publishing Pvt. Ltd, New Delhi.

EL 407

DESIGN OF ELECTRICAL SYSTEMS

Group A

Design of load boxes and rheostats.

DC machine design: Main dimensions, output equation, choice of number of poles, choice of type of winding, design of commutator and brush gear, design of field poles and field windings.

Armature windings: Basic principles and classification of armature windings, single layer and double layer windings, simple and multiple windings. Different types of AC windings, commutator windings, AC winding factors. Armature reaction in AC machines, causes and elimination of harmonics. Skin effect and eddy current losses in armature conductors. Design of different types of motor starters, field regulators.

Group B

Transformer design: Single-phase and three-phase—main dimensions, core and winding design, magnetizing current, losses, reactance of windings, tank design.

Induction motor design: Three-phase—main dimensions. Stator and rotor windings. Calculation of no load and pull out currents. Torque and speed calculations.

Distribution design: Fixing location of distribution transformer. Plotting of load curves and determination of maximum demand. Design of distributors and feeders. Design of domestic wiring.

Recommended Books

- .. A K Sawhney. Electrical Machine Design. Dhanpat Rai & Sons, Delhi.
- .. M G Say. Performance & Design of A C Machines. ELBS edition. Sir Isaac Pitman & Sons Ltd.
- .. A H Cotton. Electrical Transmission and Distribution. ELBS edition. Sir Isaac Pitman & Sons Ltd.

EL 411

ENERGY SYSTEMS

Group A

Sources of conventional energy. Fossil fuels—solid fossil fuel—coal and lignite, formation, physical properties and chemical properties. Combustion equations. Coal analyses—proximate and ultimate, determination of air/fuel ratio for coal-fired boilers.

Liquid and gaseous fossil fuels: Petroleum and natural gas. Physical and chemical properties. Combustion equations. Manufactured and byproduct gases composition, heating value, use. Air/ fuel ratio for liquid and gaseous fuel boilers.

Cogeneration and combined cycle generation. Fluidised bed combustion. Nuclear fission reactions: Fuel isotope energy release in fission. Fertile isotopes.

Converter and breeder reactors. Nuclear fusion—fusion reactions. Energy release in fusion. Advantages and disadvantages of nuclear fusion.

Hydro energy: Run of the river and pumped storage systems. Energy and power equations. Available water head. Impulse and reaction type hydro turbines.

Environmental effects of conventional energy conversion. Energy conservation and energy audit.

Group B

Different forms of non-conventional energy sources: Solar, wind, geothermal, ocean, biogas, etc.

Two types of non-conventional energy conversion processes: a) Direct conversion to electrical energy, viz, photovoltaic, fuel cells, etc.; b) Primary conversion to non-electrical energy viz. solar-thermal, wind-turbine, ocean-thermal, tidal, etc.

Solar: Terrestrial solar radiation, solar-thermal conversion, techniques of collection, storage and utilization, types of solar collectors, selective surfaces, thermal processes, power generation, etc.

Photoelectric effect, solar cells, crystalline and amorphous semiconductors as solar cell materials, equivalent circuit and efficiency considerations.

Wind: Principles of wind power, wind-turbine operation, state characteristics, small machines, large machines.

Geothermal and ocean: Origin and types of geothermal energy, vapour dominated systems, liquid dominated systems, flashed-steam type.

Ocean temperature differences, open cycle, closed cycle, ocean waves, energy and power from wave, tides, simple single pool tidal system.

Biogas: Biogas conversion mechanisms, source of waste, simple digester, composition and calorific value of biogas.

Chemical: Principles of electrochemical cell operation, fuel cells, different components of fuel cells, hydrogen-oxygen fuel cells, hydro-carbon fuel cells, Faraday's law of electrolysis and thermodynamics of electrochemical energy conversion, ideal cell voltage, ideal cell efficiency, practical limitations.

Comparative study of conventional and nonconventional energy conversion as regards efficiency, economics and environmental effects.

Recommended Books

- .. O P Gupta. Energy Technology. Khanna Book Publishing, Delhi.

.. M M El-Wakil. Power Plant Technology. McGraw Hill International Students Edition.

.. M Ali Kettani. Direct Energy Conversions. Addison Wesley Publishing Co., New York.

EL 412

POWER ELECTRONICS

Group A

Devices

Power diodes, uncontrolled rectification and power loss during transients. Bipolar junction transistor. Power MOSFET, IGBT, GTO and LASCR, UJT, UJT oscillator, its design and frequency stability.

Driver circuit, pulse transformer and opto coupler. Thyristor, 2-transistor analogy, triggering circuits, dv/dt and di/dt protections, snubber circuit and its design.

Cooling and heat sinks. Natural and forced commutations. DC choppers, step-down and step-up operations, thyristor choppers and switching mode regulators.

Group B

Applications

B1-2, M-2, B-6 and M-6 half/ full controlled circuits with R and R-L loads. Principle of phase control, circuits for control and UPS. 1- and 3-... cycloconverter and harmonic reduction.

Inverters: Series inverter, domestic inverter, PWM inverter, auxiliary commutated thyristor inverters, complementary commutated thyristor inverters, current source inverters, 12-pulse converters and hvdc link.

D.C. drives: one-phase semiconverter/ full-converter drives, 3-phase semiconverter/ full/ dual-converter drives, 2/ 4-quadrant chopper drives.

Induction motor drives, V/f control and closed-loop control.

Recommended Books

.. Muhammad H Rashid. Power Electronics. Prentice Hall of India (P) Ltd., New Delhi.

.. C W Lander. Power Electronics. McGraw-Hill International.

.. G K Dubey. Power Electronics. New Age International (P) Ltd., New Delhi.

EL 413

HIGH VOLTAGE ENGINEERING AND POWER APPARATUS

Group A

Breakdown phenomena: Breakdown of gaseous medium, mechanism of charge multiplication, secondary emission, Townsend theory, Streamer theory, Paschen's law, corona effect of polarity of voltage on corona and breakdown process.

Breakdown of solid: Intrinsic breakdown, thermal breakdown, electro-mechanical breakdown, streamer breakdown.

Breakdown of liquid: Breakdown of commercial liquid, cavitation theory, bubble theory, suspended particle theory.

Insulating materials. Properties of traditional insulating materials, SF₆, vacuum, air, insulating oils, ceramics, epoxy resins, PVC, PTFE, PMMC, fibreglass, polyethylene.

Insulation resistance. Tacking index. Electrical and mechanical properties of insulators used in transmission line. Different types of line insulators. String efficiency, bushings, general design approach of bushing.

Cables: Different types of cables. Paper insulated cables, XLPE cables, gas-filled cables, technology and principles. Generation of travelling waves in transmission lines, reflection and transmission constants.

Power system grounding: Solid grounding, resistance grounding, reactance grounding, grounding through earthing transformer, resonant grounding.

Group B

Voltage surges: Lightning phenomena, lightning induced overvoltage, direct stroke, indirect stroke. Protection of power stations and sub-stations and transmission line against direct strokes.

Protection of electrical apparatus against travelling waves. Lightning arrestors—expulsion type, valve type, magnetic blow-out type and metal oxide type.

Insulation co-ordination: Determination of the line insulation, basic impulse level and insulation level of substation equipment. Selection of lightning arrester. Establishment of impulse withstand level. Overvoltage due to switching. Reduction of switching overvoltage.

Generation of high voltage and current in high voltage laboratory. Generation of high AC, DC and impulse voltage. Generation of high impulse current, impulse generator, testing transformer, source resonant circuit.

Non-destructive testing of materials and electrical apparatus. Measurement of DC resistivity, measurement of dielectric constant and loss factors, partial discharge measurement.

Preventive testing of insulation: High voltage testing of insulators, bushings, cables and transformers. High voltage testing of surge diverters.

Recommended Books

.. E Kuffel and Abdullah. High Voltage Engineering. Pergamon Press (International edition).

.. P N Naidu and K Kamaraju. High Voltage Engineering. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

.. M L Soni, et al. A Text-book on Power System Engineering. Dhanpat Rai and Sons, Delhi.

POWER SYSTEM PERFORMANCE

Group A

An overview of modern power system: Layout of typical power system—generating station, substation, transformer, transmission line, distribution, load. Symbols and circuit representation of various components of the system. Single linediagram.

Per unit method of calculation: Base quantities and per unit values, modification of per unit values due to change of base, equivalent circuit of transformer on per unit basis, choice of base quantities for power system analysis, advantages of per unit method of calculation, per unit impedance diagram of a power system.

Symmetrical components: Transformation of voltage, current and impedance to symmetrical component system, complex power in terms of transformed voltage and currents, positive, negative and zero sequence impedances of different power system components; equivalent circuits in terms of symmetrical component quantities, advantage of symmetrical component representation.

Fault studies: Symmetrical three-phase fault calculation, fault MVA and circuit breaker capacity, current limiting reactor, their placement and usefulness.

Unsymmetrical faults, classification, analysis of L-G, L-L and L-L-G fault using symmetrical components, equivalent circuit for representation of different kinds of faults, calculation of fault current and post-fault voltages. Arcing ground, its consequences and remedy.

Load flow study: The basic load flow problem and its importance, classification of system bus bars, formulation of load flow equations using bus admittance matrix, iterative solution of load flow equations by Gauss-Seidel method, acceleration for convergence.

Economic load despatch: Generation cost, incremental cost, optimal loading of generators on a common bus bar, transmission loss formula, incremental transmission loss, generation scheduling taking care of transmission loss.

Group B

High voltage d.c. transmission: Historical review, merits and limitations of d.c. transmission, kinds of d.c. links, constitution of d.c. links, terminal equipment transformer, converter, choke and filter; gate control and operation of three-phase thyristor bridge as rectifier and inverter, relationship between input and output voltage and current in the bridge converter, active and reactive power; control of current and voltage in a d.c. link, back-to-back connection and its usefulness.

Power system control: Automatic load frequency and voltage control, speed governor, load sharing among synchronous generators, exciter, brushless excitation system.

Power system stability: Transient power output of a synchronous machine, effect of voltage regulator and governor on enhancement of transient stability. The swing equations in multi-machine system, numerical method of solution of swing equations and assessment of transient stability.

Power system protection: Electromagnetic relays, construction and operating principle of attracted armature, induction disc and induction cup type relay, inverse time lag relay, plug setting and time setting arrangement.

Overvoltage, overcurrent, earth fault and neutral displacement protection. Primary and backup protection, co-ordination of overcurrent relays in radial feeder protection, directional overcurrent relay, ring main and parallel feeder protection.

Distance protection for transmission lines, three zone protection, tripping circuit, impedance setting for earth fault and phase fault types relays. Errors in distance measurement, arcing fault, power swing, directional, reactance, mho, ohm and quadrilateral characteristics.

Differential protection schemes for generator and transformer, other protections of generator and transformer.

Pilot wire relays for feeders and cables, carrier relays—blocking and inter-tripping schemes, carrier equipment, carrier phase comparison.

Recommended Books

.. I J Nagrath and D P Kothari. Modern Power System Analysis. Tata McGraw Hill Publishing Co. Ltd., New Delhi.

.. A R Van C Warrington. Protective Relaying—Vol. I. Chapman and Hall, UK.

MICROPROCESSORS AND MICROCONTROLLERS

(See page 36, subject CP 425)

ADVANCED ASPECTS OF ELECTRICAL MACHINES

Group A

Synchronous motor analysis taking armature resistance into account, vector diagrams, power circle and excitation circle—diagrams. Performance calculations under various operating conditions.

The equation of motion or 'swing' equation for synchronous motors and generators. Solutions of linearized swing equation, small oscillations of synchronous machines. Hunting of synchronous motors, elements of large oscillation of synchronous machines, concept of transient stability.

Starting of synchronous motors with the help of damper windings, George's phenomenon. Brushless excitation of synchronous generators and motors.

Synchronous-induction motor: Slip-ring induction motor run as synchronous motor. Different types of motor excitation. Starting and running characteristics-combined synchronous motor and induction motor circle diagrams, performance calculation, design features.

Concept of negative sequence and zero sequence reactances of synchronous machines.

Group B

Inverter operation of induction motors, space and time harmonics and their effects on the performance of induction motors.

Induction generators: Operation from bus-bars, self-excitation equivalent circuits and performance—its utility in wind power generation.

A.C. commutator machines: General construction. Derivation of generalized expressions: (a) Transformer e.m.f. and rotational e.m.f.'s in phase windings; (b) Transformer and rotational e.m.f.'s in commutator windings, uncompensated and compensated series motor; vector diagrams, circle diagram, operational characteristics and design features.

Variable reluctance and fractional and sub-fractional h.p. motors: Different types of reluctance and stepper motors, permanent magnet motors, derivation of performance equations. Control schemes and performance.

Recommended Books

- .. P S Bimbhra. Electrical Machines. Khanna Book Publishing, New Delhi.
- .. A E Fitzgerald, C Kingsley and S Umans. Electrical Machinery. McGraw-Hill International.
- .. M G Say. Performance of A C Machines. ELBSEdition.
- .. E O Taylor. The Performance and Design of A C Commutator Motors. S Chand & Co. Ltd., New Delhi.

EL 422

POWER ELECTRONICS

(See page 44, subject EL 412)

EL 423

ELECTRICAL DRIVES

Group A

Basic concepts. Dynamics of electric drives.

Mechanical system—different speed/torque characteristics of different frictional system, windage torque. N-T characteristics of different industrial systems, four quadrant operation of drive systems, dynamic conditions of a drive system, steady state and transient stability of electrical drive.

Drive motors: DC motor, three-phase induction motor and synchronous motor characteristics require power losses,

temperature restrictions, heating and cooling, different modes of operation (continuous/ short time intermittent duty/ periodic intermittent duty), selection of motors.

Drive motor power supply: A general survey of different power supply systems for motor drive. Phase controlled line commutated converters.

DC choppers.

Inverters.

Cyclo converters. AC voltage controllers.

Group B

Control of electric motors: DC drives—1 Φ and 3- Φ converter drives. Chopper drives, closed loop control of DC motor.

AC drives: 3- Φ induction motor control, starter voltage control/ rotor voltage control, voltage and frequency control, current control, closed loop control of 3- Φ induction motor.

Synchronous motor control: Voltage and frequency control, closed loop control of synchronous motors.

Recommended Books

- .. V Subrahmanyam. Electric Drives—Concepts and Applications. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. Muhammad H Rashid. Power Electronics. Prentice-Hall of India (P) Ltd., New Delhi.
- .. N K De and PK Sen. Electric Drives. Prentice-Hall of India (P) Ltd., New Delhi.

EL 424

ELECTRICAL POWER UTILISATION

Group A

Radiation and vision: Physics of light-wave theory, quantum theory, unified theory, photon generation, visible wavelength range, standard observer curve, different forms of energy converted to visible radiation, spectral power distribution curve.

Quantities, units, standards and measurement: Luminous energy, luminous flux, spectral radiant flux, solid angle, luminous intensity, luminance, illuminance, luminous efficacy.

Colour temperature, colour rendering index, reflectance, diffuser, etc. Lambert's cosine law, inverse square law and cosine law of illumination. Polar curve, Rousseau's diagram, illuminance (flux) meter, bench photometer (intensity measurement), integrating sphere (flux measurement).

Optical system of human eye.

Sources of light: Construction and electrical circuits of different sources of light, filament lamps, halogen lamps, discharge lamps—sodium and mercury high pressure discharge lamps, tube and CFL lamps.

Lighting calculations for indoor and outdoor applications:

Shop lighting, factory lighting, street lighting, flood lighting.

Group B

Electric heating, welding and electroplating: Induction heating—principle of operation, scope of high frequency and low frequency heating, induction heating, power supplies at different frequencies.

Induction heating furnaces—coreless and core types.

Arc heating: AC arc heating—different arc electrodes, direct and indirect arc furnace and their power supply systems, electrode regulators, condition for maximum output, necessity of reactor in arc furnace, general arc furnace transformer construction, energy balance in arc furnace, advantages of direct arc furnaces.

DC arc furnace supply system, different bottom electrodes, twin shell DCEAF (electrode arc furnace) system, advantages of DC arc heating.

Dielectric heating: Principle of operation, choice of voltage and frequency, electrode configuration.

Resistance heating: Different resistance heating materials and their properties, causes of failures.

Direct and indirect resistance heating furnace. Design of resistance elements.

Electric welding: Resistance and arc welding and equipment for such welding.

Electrolysis: Application of electrolysis, electro deposition, electro extraction, electro refining.

Recommended Books

.. H Hewitt and A S Vause. Lamps and Lighting. Edward Arnold (Publishers), London.

.. G C Garg Utilisation of Electric Power & Electric Traction. khannabooks.com, Delhi.

EL 425

MICROPROCESSORS AND MICROCONTROLLERS

(See page 36, subject CP 425)

EL 431

CONTROL THEORY

Group A

Continuous-time systems: Performance specifications in time-domain and frequency domain. Correlation between time domain and frequency domain specifications.

Error coefficients. Design approaches. Frequency domain vs S-plane design. Types of compensation. Controllability and observability of control systems.

Cascade compensation: Lead, lag, and lag-lead compensators.

Use of Bode diagram. Root locus, and Nyquist diagram for compensator design. Feedback compensator design, use of inverse Nyquist diagram, minor loop feedback compensation. PID controllers.

Linear state variable feedback. Pole placement using state variable feedback.

Nonlinear systems: Types of common non-linearities. Properties of non-linear systems. Available techniques for analysing non-linear systems. Linearising approximations. Describing function techniques. Detecting limit cycling and instability. Phase plane methods.

Lyapunov's stability criterion. Popov's method for stability analysis of non-linear systems.

Group B

Discrete-time systems: Introduction to discrete-time systems.

Z-transforms, inverse Z-transforms and bi-linear transformations.

Pulse transfer functions. Tune response of sampled data systems. Effect of sample hold and dead times.

Frequency response: Bode plots, polar plots and gain (db) vs. phase plots. Stability using Jury criterion, Routh-Hurwitz criterion, Nyquist criterion, Bode plot and root locus. Design of compensators in Z-domain and W domain.

State space representation of discrete systems and sampled-data systems. Deriving Z-transfer function model from state model of discrete systems. Solving time invariant state equations. State transition matrix. Controllability and observability of time-invariant discrete systems.

Recommended Books

.. I J Nagrath and M Gopal. Control Systems Engineering. New Age International (P) Ltd., New Delhi.

.. M Gopal. Control Systems: Principles and Design. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

.. A Ambikapathy. Control Engineering. Khanna Books, New Delhi.

.. B C Kuo. Digital Control Systems. Holt-Saunders International edition, Japan.

EL 432

POWER ELECTRONICS

(See page 44, subject EL 412)

EL 433

PROCESS CONTROL SYSTEMS

Group A

Process control principles, process control block diagram, loop

components—sensor and transmitter, controller, final control element. Process transfer functions—process lag and dead time, self-regulating and non-self-regulating processes.

Process instrumentation diagram: Symbols and interconnections.

Process control sensors and transmitter, thermal sensors, mechanical sensors, analog signal conditioning—instrumentation amplifier, signal isolation, and filter.

Analog signal transmission systems.

Analog process controller, P, PI, PD and PID modes of operation, controller-tuning methods, on-off controllers, anti-integral windup, anti-derivative kick and controller saturation. Velocity or incremental controller. Design of analog process controller. Pneumatic process controllers—pneumatic amplifiers and relays.

Digital process controllers—theory. Digital controller in a process control loop, analog-to-digital and digital-to-analog converters. Realization of digital controller.

Final control elements: Actuators, positioners and control valves.

Recorders: Analog, digital and data loggers.

Group B

Control loop characteristics. Controllability and stability—root locus and Bode plot techniques.

Control schemes. Ratio-control, cascade control, feedforward control and multi-loop control. PID control. Process loop tuning—process reaction method. Ziegler-Nichols method and frequency response methods.

Characteristics of chemical processes. Heat exchangers, distillation columns, chemical reactors, pH and blending processes, delay time and its effect. Flow control, pressure control, level control, and temperature control. Boiler control—feed water control, drum-level control, combustion control and 3-point control.

Computer control of processes. Direct digital control and supervisory control. Adaptive control systems.

Recommended Books

- .. C Johnson. Process Control Instrumentation Technology. Prentice-Hall of India (P) Ltd., New Delhi.
- .. D Patranabis. Principles of Process Control. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. P Harriett. Process Control. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

EL 434

INSTRUMENTATION SYSTEMS

Group A

Instrument performance characteristics and specifications. Static and dynamic, analog and digital instruments. Errors in measurements—error, correction, precision, accuracy, statistical analysis of errors, mean, median, mode, standard deviation. Confidence intervals.

Cathode Ray Oscilloscope (CRO), use of CRO in voltage measurements and waveform display.

Measurements of kVAh and kVARh in three-phase load, trivector meter, summation metering, summation current transformer.

Use of IVD in impedance comparison, low resistance comparison by using IVD.

Study of bridge balance convergence and bridge sensitivity in four-arm a.c. bridges, quad bridge for comparison of resistance with standard calculable capacitor.

Group B

A/D and D/A converters, digital voltmeters and multimeters, use of flip-flop circuits in up-down counters, digital displays.

Electrical transducers, linear variable differential transformers (LVDT), strain gauge, fluid flow and pressure measurements, temperature transducer, light and radiation transducer.

Introduction to instrumentation amplifier, CMRR and active filter, sample and hold circuit, data transmission in digital instrument systems and PC, IEEE-488 bus, introduction to long distance data transmission (modems).

Recommended Books

- .. E Frank. Electrical Measurement Analysis. McGraw-Hill International.
- .. A P Malvino and D Leach. Digital Principles and Applications Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. D Patranabis. Principles of Industrial Instrumentation. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. A D Helfrick and W D Cooper. Modern Electronic Instrumentation and Measurement Techniques Prentice Hall of India (P) Ltd., New Delhi.

EL 435

MICROPROCESSORS AND MICROCONTROLLERS

(See page 36, subject CP 425)

ELECTRONICS AND COMMUNICATION ENGINEERING

The Revolution of the 21st Century

Electronics and communication engineering is the branch of science and technology relating to the flow and control of electricity through semiconducting and other materials or through vacuum. Electronics is concerned with the study and applications of the motions of charge carriers (electrons, holes and ions) under the influence of externally applied voltage or current, or in relation to the incidence or production of radiant energy. While electronics is properly a part of electrical engineering, the latter term is often reserved for applications involving power generation, distribution and use at low frequencies, for example, in utility systems and industry. Since the 1960s, the dominant segment of electronics has been known as solid state, which involves transistors and other semiconductor devices and assemblies.

Barrier Breaking Communique

Communication engineering started gaining momentum after the wide application of telegraph system, invented by Samuel Morse in 1832, replacing the semaphore communication. Telephone, invented in 1876 by Graham Bell, created a sensation. Electronic devices, however, resulted from a by-product of Thomas Edison's research on the incandescent lamp. He discovered in 1883 that a weak electric current would flow across a partial vacuum between a heated filament and a metallic electrode. Involvement of J J Thomson, Rutherford and Sir Ambrose Fleming in development of telegraph and illumination gave rich dividends. Fleming's two-electrode valve in 1904, followed by invention of triode by Lee De Forest in 1906, laid the foundation stone of a new branch with new hopes.

Around the same time, that is, by the late Nineteenth Century, Maxwell laid the theoretical foundation of electromagnetics. The significance of his work was realised through the pioneering work on wireless communication by the



Radar Antenna

likes of Sir J C Bose, Herz and Marconi, the invention of transistor by John Bardeen, Welner Brattain and William Shockley of Bell Laboratories in 1948 and subsequent improvements. Development

Electronics and Communication Engineering is the study and application of electron, hole and ion motion, including the means of producing them, the laws governing them and means for controlling them for useful application in the scientific, industrial and communication purposes. This is one of the branches of engineering which embraces a broad field of scientific and industrial effort without clear boundaries. The application is concerned with the design, manufacture, management and application of electron tubes and solid state components in various devices like radio, television,

of integrated circuit revolutionised the application of electronic components in terms of improving life and reliability, but reducing the size, weight and cost.

Indian Scenario

In India, the first telegraph line between Calcutta and Diamond Harbour was opened for traffic as early as in 1851. The telephone service was also introduced in Calcutta in 1881-82 barely six years after the invention of the telephone.

Broadcasting started in 1937. Television service made its beginning at New Delhi on September 15, 1959. Satellite communication also is being utilised since 1965.

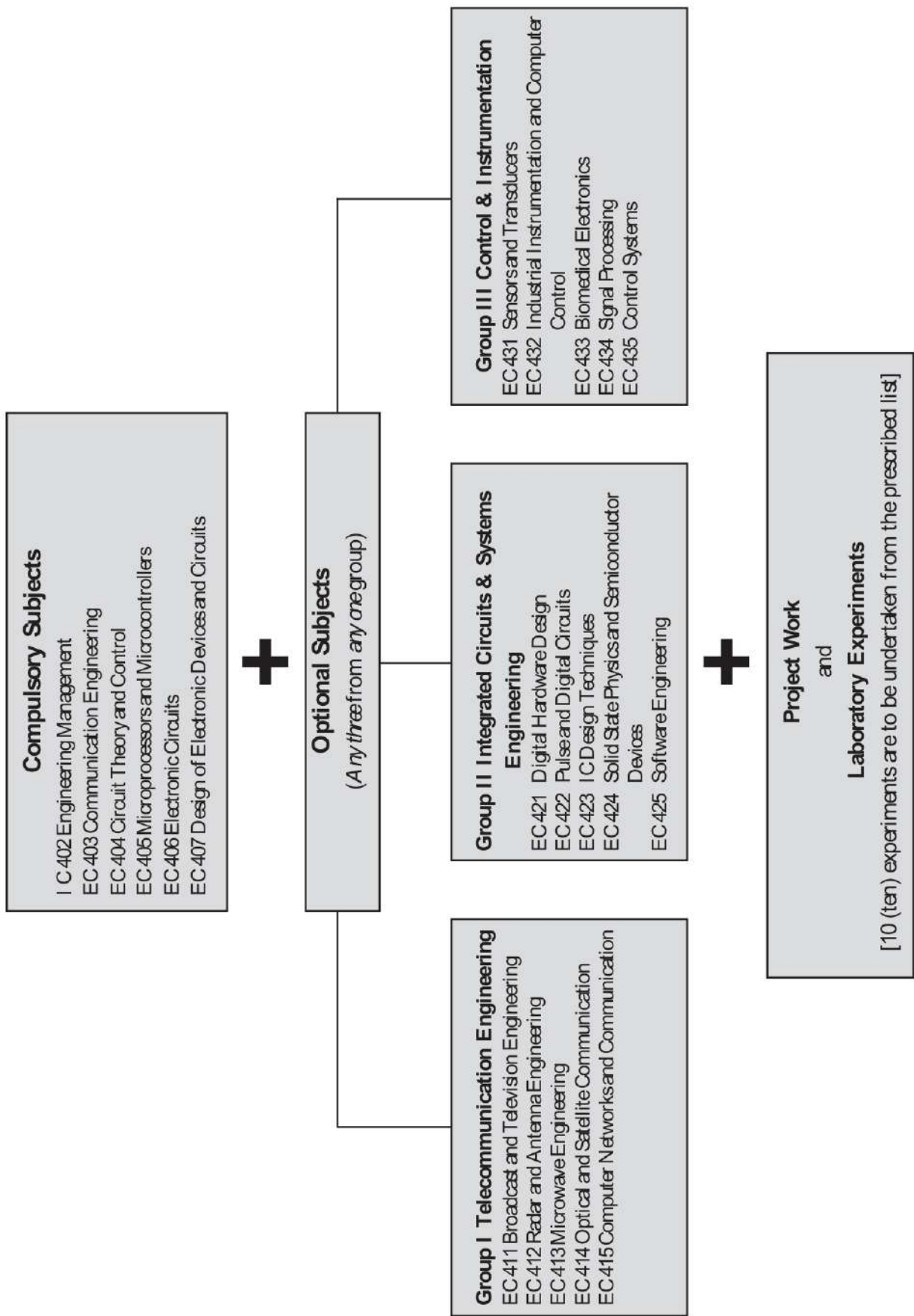
India has a strong R & D base in electronics through the various laboratories under the Department of Space, the Department of Atomic Energy, the Ministry of Defence, the Ministry of Communication and other user Ministries, as also the academic institutions of national importance. Besides these, a number of production agencies have strong inhouse R & D groups.

A number of special manpower development programmes for the growth of electronics have been initiated and specialised courses have been designed which are being implemented through the UGC. Centres for Electronic Design Technology (CEDT) have been imparting training to engineers in latest design techniques in electronics.

In 1970, the Government had set up a separate Department of Electronics to guide the growth of this vital industry in a balanced manner. Electronics Commission, constituted in February 1971, formulates policies in the field for achieving an integrated and self-reliant base in the country.

Some of the leading organisations engaged in the field of Electronics & telecommunication engineering are: Electronics & Technology Development Corporation; Semiconductor Complex Ltd; Centre for Development of Telematics; Electronics Corporation of India Ltd; Central Electronics Engineering Research Institute; Central Scientific Instruments Organisation; Indian Telephone Industries; Telecommunication Research Centre, etc. Besides these, a number of state-owned Electronics Development Corporations are actively involved in frontier areas of electronics and telecommunication engineering.

ELECTRONICS & COMMUNICATION ENGINEERING



ELECTRONICS AND COMMUNICATION ENGINEERING

IC 402

ENGINEERING MANAGEMENT

(See page 13, subject IC 402)

EC 403

COMMUNICATION ENGINEERING

Group A

Field theory: Fields, vector calculus, gradient, divergence, curl, Gauss's laws, Stoke's theorem, Helmholtz theorem. Electric field intensity and potential, conducting boundaries, coaxial cylinders, Poisson's equations and Laplace equation. Ampere's circuital law, differential equation for vector potential. Magnetic polarization and field intensity, boundary conditions for B and H. Faraday's law. Time varying fields, displacement current. Maxwell's equations in differential and integral forms.

Communication preliminaries. Signal representation in frequency and time domain. Fourier transforms, power spectrum, energy density spectrum. Direct delta function. Orthogonal representatives of signals (Gram Schmidt procedure), autocorrelation, sampling theorems (Nyquist criterion). Random signal theory. Discrete probability theory, continuous random variables, probability density functions, ergodic processes, correlation function, spectral density, white noise.

Noise: Atmospheric, thermal, shot and partition noise, noise figure and experimental determination of noise figure, minimum noise figures in networks.

Analog communication. Modulation theory and circuits. Amplitude modulation, AM-DSB, AM-DSB/SC, AM-SSB and their comparison. Modulating and detector circuits for AM, FM and phase modulation. Automatic frequency control. Pulse modulation. PAM, PDM, PPM, PCM, delta modulation and circuits. Principle of multiplexing FDM and TDM.

Group B

Transmission through network: Networks with random input, auto-correlations, spectral density and probability density input-output relationships, envelope of sine wave plus Gaussian noise, optimum systems and nonlinear systems. Maximum signal to noise ratio criterion. Minimum mean square error criteria, equivalent noise bandwidth. SNR in envelope detectors and PCM systems. Comparison of modulation systems.

Digital communication: Basic information theory: Definition of information, entropy, uncertainty and information, rate of communication, redundancy, relation between systems capacity and information content of messages, discrete systems, discrete noisy channel, channel coding.

Introduction to digital communication, quantization, PCM, log-PCM, DM, DPCM, AD, PCM and LPC for speech signals, TDM. Baseband transmission, optimum detection, matched filter, optimum terminal filters. ISI pulseshapes for controlled ISI, line codes; digital RF modulation. Modems, performance of digital modulation systems Synchronization. Timing recovery.

Recommended Books

- .. J D Kraus and D Fleisch. Electromagnetics with Applications McGraw-Hill International, Tokyo.
- .. B A Carlson. An Introduction to Signals and Noise in Electrical Communication. McGraw-Hill International, Tokyo.
- .. G Kennedy. Electronic Communication Systems. Prentice-Hall of India (P) Ltd., New Delhi.
- .. M Schwartz. Information Transmission, Modulation and Noise. McGraw-Hill International, New York.

EC 404

CIRCUIT THEORY AND CONTROL

Group A

Graph of a network. Concept of tree, concepts of loop current and nodepair voltage, circuits cut-set and cut-set matrices, formulation of equilibrium equations of the loop and node basis. Mesh and nodal analysis.

Laplace transform. Transient response using Laplace transform. Initial and final value theorems. Unit step, impulse, ramp functions. Laplace transform for shifted and singular functions.

The convolution integral, Fourier series, complex exponential form of the Fourier series. The frequency spectra of periodic waveforms and their relationship to Laplace transform.

The concept of complex frequency, transform impedance and admittance; series and parallel combinations. Frequency response, coupled circuits.

Terminals and terminal pairs, driving point impedance, transfer functions, poles and zeros, restrictions on pole and zero locations in s-plane. Analysis of 1-port and 2-port networks. Time domain behaviour from pole and zero plot, sinusoidal network functions in terms of poles and zeros. Resonance, Q and bandwidth of a circuit.

Introduction to synthesis of passive networks: Butterworths, Chebyshev and Bessel type low pass, high pass, band pass and band rejection filters.

Group B

Introduction: Basic concepts and symbols, open loop and closed loop systems, effects of feedback. Concepts of linear and nonlinear systems. Definition of transfer function. Block diagram representation. Signal flow graphs.

Servo components: Mathematical modelling and simulation of dynamic systems. Synchros, potentiometers, gyros. d.c. and a.c. servomotors. d.c. and a.c. tachogenerators. Power and preamplifiers. Modulators and demodulators. Position and speed control systems.

Time response: Typical test input signals. Time domain performance of first and second order systems to impulse, step, ramp and sinusoidal inputs. Definition of error coefficients and steady state error.

Stability: Routh-Hurwitz criteria

Frequency response: Frequency domain specifications. Bode plots. Polar plots.

Regulators and controllers. Proportional, PI and PID controllers.

Recommended Books

- .. M E Van Valkenburg Network Analysis Wiley International, New York.
- .. Ashfaq Hussain. Network and Systems. Khanna Books Publishing, New Delhi.
- .. K Ogata. Modern Control Engineering. Prentice-Hall of India (P) Ltd., New Delhi.
- .. B C Kuo. Automatic Control Systems Prentice-Hall of India (P) Ltd., New Delhi.

EC 405

MICROPROCESSORS AND MICROCONTROLLERS

(See page 36, subject CP 425)

EC 406

ELECTRONIC CIRCUITS

Group A

Biasing techniques of BJT and FETs; Bias stability; Self-bias, hybrid II model of BJT and high frequency response.

Single stage amplifiers—bipolar amplifiers, CE, CB, CC configurations, characteristics, gain, h-parameters, analysis using h-parameters. FET amplifiers.

Multistage amplifiers—classification, distortion, frequency response, step response, RC-coupled amplifiers, transformer coupled amplifiers.

Feedback amplifiers—concept, gain with feedback, negative feedback—example of Boot strapped CE amplifier, advantages and limitations, input and output impedance, voltage-series, voltage-shunt, current-series, current-shunt feedback amplifiers.

Stability and oscillators—condition of oscillation, sinusoidal oscillator, phase shift oscillator, resonant circuit oscillator, Wein bridge oscillator, crystal oscillator, stability of frequency.

Operational amplifiers—differential amplifiers, transfer characteristics, IC op-amp functions, frequency response, step response; introduction to analog computer.

Power amplifiers—class A, B, AB, C amplifiers, distortion, efficiency, push-pull principle, power supply—half wave, full wave, ripple factors, filters, regulation.

Group B

Introduction, binary numbers, binary codes.

Boolean algebra—functions and expressions, gates—OR, AND, NOT, NOR, NAND, De Morgan's theorem, laws and theorems.

Minimization of logical functions—Karnaugh map.

Arithmetic circuits—Ex-OR gate, half adder, full adder, subtraction, code conversion, etc.

Basic gate structures—RTL, DTL, TTL, ECL, MOS, CMOS.

Flip-flops—RS, T, RST, D, JK, Schmidt trigger, astable, monostable.

Counter techniques—Ripple counter, parallel counter, BCD counter, synchronous counter, ring counter.

Shift registers, memory.

D/A and A/D converters.

Recommended Books

- .. J Millman and C C Halkias Integrated Electronics. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. J Millman and C C Halkias Electronic Devices and Circuits. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. AK Maini. Electronics Simplified All-In-One www.khannabooks.com. Khanna Books, New Delhi.
- .. John D Ryder. Electronic Fundamentals and Applications. Prentice-Hall of India (P) Ltd., New Delhi.

EC 407

DESIGN OF ELECTRONIC DEVICES AND CIRCUITS

Group A

Introduction to linear ICs. Operational amplifiers and their basic applications; audio/ radio/ video ICs and their specifications.

Power supplies. Rectifiers, filters and electronic stabilization circuits, considerations regarding ripple, regulation and efficiency, short circuit protection; polyphase rectifiers, electronic converters, applications in industry. Introduction to UPS.

IC voltage regulators. Positive and negative voltage regulators, adjustable voltage regulators, high current short circuit protected regulators, dual tracking regulations, programmable supply, current regulators, switching regulators, fold back current limited and shutdown circuits.

Amplifiers: Inverting amplifiers, non-inverting amplifiers, differential amplifiers, integrator and differentiator, logarithmic amplifiers and multipliers, filters, voltage to frequency converters, sample and hold circuit, high input impedance amplifiers, instrumentation amplifiers, sensing amplifiers and comparators, zero crossing detector.

Group B

Oscillators. Expression for oscillation frequency and conditions for maintenance of oscillations, sine wave oscillators, multivibrators, function generators, voltage controlled oscillators, crystal oscillators.

Communication circuits. RF and IF amplifiers, video amplifiers, AM detectors, balanced modulators and demodulators, phase locked loop, FM demodulation, frequency shift keying, frequency multiplication.

Digital systems. Frequency counters, A/D and D/A converters, digital voltmeters, programmable digital generators, frequency synthesizer. Design of ALU.

Recommended Books

- .. B S Sonde. Introduction to System Design using Integrated Circuits. New Age International (P) Ltd., New Delhi.
- .. Rishabh Anand. Linear Integrated Circuits. Khanna Books Publishing Co., New Delhi.

EC 411

BROADCAST AND TELEVISION ENGINEERING

Group A

Microphones, loudspeakers, recording and reproduction of sound—disc, tape, film recording, playback system. High fidelity equipment for reproduction of sound. Loudspeaker enclosures and baffles. Stereophonic sound system.

Studios and auditorium: Theory of reverberation, its limitation, measurement and adjustment. Acoustic materials, design considerations of broadcasting studios and auditorium.

Broadcast transmitters—master oscillators, frequency multiplier, high and low level modulation system. Class A, AB, and C power amplifiers, feeder lines.

Block diagram and principles of amplitude modulated and frequency modulated transmitters. Studio equipment and control room apparatus. OB equipment and receiving centre's facilities.

Superhetrodyne receiver, communication receiver. Intermediate frequency, image frequency. Receiver characteristics and measurement. Design considerations of modern broadcast transmitters and receivers. Transmitting and receiving antennas. FM transmitters and receivers.

Group B

Television system and standards—FCC and CCIR-B standards and their comparison.

Theory of scanning—progressive scanning, interlaced scanning. Video bandwidth.

Composite video signal—Hoz. Sync, hoz. blanking, equalizing pulses, serrations, block diagram of sync. generator.

Television pick-up tubes and cameras—vidicon, plumbicon, saticon, etc., CCD image sensors, picture tube, output coupling circuit.

Television broadcast studio facilities, block diagram of television transmitter. Digital television.

Design considerations of transmitter and receiver. Feeder line, Balun, diplexer, vestigial side band filters. Transmitter-receiver relationship, RA and TA system. Transmitting and receiving antennas.

Block diagram of intercarrier type television receiver, RF tuner, mixer and 10-circuit design. Sync. separator. IF amplifier characteristics and design. Trap circuit.

Elements of colour television, colour vector diagram, colour difference signal, I, Q, Y signals and their bandwidths. Colour cameras and picture tubes, colour killer circuit, compatibility.

Propagation of television signal, telecine, CCTV, CATV, MATV, TV booster, VCR, VCP.

Recommended Books

- .. A M Dhake. Television and Video Engineering. Prentice-Hall of India (P) Ltd., New Delhi.
- .. Bali & Bali. Audio Video Systems. Khanna Book Publishing Co. (P) Ltd., New Delhi.

EC 412

DESIGN OF ELECTRONIC DEVICES AND CIRCUITS

Group A

Block diagram of pulse radar. Radar equation. Signal-to-noise ratio, probability density function and range, ambiguities, radar cross-section of target, target models, PRF, system losses.

CW and frequency-modulated radar doppler effect, CW radar, FMCW radar.

MTI and pulse doppler radar—delay line cancellers and characteristics, blind speeds, doublet cancellation. MTI radars with power amplifier and power oscillators, transmitters. MTI from moving platform, pulse doppler radars. Tracking radars.

Tracking techniques—sequential lobing, conical scan monopulse. Tracking in range, acquisition. Tracking performance.

Electronic scanning radar system, beam forming and steering methods, fire controlled radar. SAR.

Radar transmitters, magnetron oscillators, hard tube and line-type pulser. Radar receivers, mixer amplifier, receiver noise, duplexers, displays, clutters, weather and interferences, system engineering and design. Pulse compression radar.

Group B

Fundamentals of radiation mechanism, vector potentials, radiation from current elements, radiation pattern, superposition and reciprocity theorems.

Small antennas, images, small antenna above ground, different types of linear arrays, multiplication of patterns, binomial arrays, antenna gain, effective area, antenna impedance, beam width, self and mutual impedance, folded dipole, Yaginda antennas.

Mathematical theories of antennas, aperture antennas, slot antennas, cavity back slot antennas, horn antennas, waveguide radiator, parabolic reflectors, Cassegrain antennas.

Broad band antennas, microstrip antennas, noise consideration, antenna measurements.

Recommended Books

- .. M I Skolnik. Introduction to Radar Systems Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. E C Jordan and K G Balmain. Electromagnetic Waves and Radiating Systems. Prentice-Hall of India (P) Ltd., New Delhi.
- .. R E Collin. Antenna and Propagation. McGraw-Hill International, Tokyo.

EC 413

MICROWAVE ENGINEERING

Group A

Wave propagation through waveguides—rectangular, circular, elliptical—cutoff frequency, modes, group and phase velocities. Cavity resonators and filters.

Network representations of discontinuity—S-matrix. Impedance transformation and matching technique.

Microwave passive components—Tee junctions, magic tee, couplers, circulators, attenuators, phase shifters, bends, twists, corners, irises, windows.

Group B

Microwave generators and amplifiers—thyristor, magnetrons, TWTs, BWOs, transistors, tunnel diodes, PIN GUNN, etc. Parametric amplifier. Ferrite and ferrite devices.

Microwave propagation and link design.

Microwave measurements, network analyser concept. Anechoic chambers.

Microwave integrated circuits—MMIC, strip and microstrip lines, slot and coplanar lines.

Recommended Books

- .. Y Liao. Microwave Devices and Circuits. Prentice-Hall of India (P) Ltd., New Delhi.
- .. P A Rizzi. Microwave Engineering Passive Circuits. Prentice-Hall of India (P) Ltd., New Delhi.
- .. Monojit Mitra. Microwave Engineering. Dhanpat Rai & Sons, Delhi.
- .. S K Roy and Monojit Mitra. Microwave Semiconductor Devices. Prentice-Hall of India (P) Ltd., New Delhi.

EC 414

OPTICAL AND SATELLITE COMMUNICATIONS

Group A

Optical fibre—step index, graded index, material, preparation, measurement of propagation, properties, jointing, connectors and couplers. Fibre optic communication systems.

System model. Optical channel—space, fibre optic, sources—lasers, LEDs.

Fibre laser for optical communication through guided media.

Modulation techniques—direct modulation and indirect modulation— injection modulation, A/O, E/O modulation techniques.

Optical detection—PIN diodes and APDs.

Optical communication systems— analog and digital communication system. Low bandwidth/ low bit rate to ultra wideband/ ultra high bit-rate communication system.

Introduction to communication networks—LANs, MANs and WANs.

Group B

Satellite launching and control. Orbits. Launch vehicles and rockets. Space shuttles. Propagation characteristics—attenuation, noise, space environment. Frequency bands.

Types of satellite systems. Satellite sub-system, power communication, control, thermal.

Earth station equipment. Satellite link design—power budget, EIRP, G/T ratio of receivers, CNR of satellite system.

Multiple access technique, TDMA, FDMA, CDMA, SPADE. Multiple beams—spot beams.

Recommended Books

- .. J M Senior. Optical Fibre Communications: Principles and Practice. Prentice-Hall of India (P) Ltd., New Delhi.
- .. T Pratt and C W Bostian. Satellite Communications. John Wiley and Sons, New York.
- .. G Keiser. Optical Fibre Communications. McGraw Hill International, New York.
- .. T T Ha. Digital Satellite Communications. McGraw-Hill International, New York.

EC 415

COMPUTER NETWORKS AND COMMUNICATIONS

Group A

Introduction. Principles of data communications: Analog and digital transmission, multiplexing, transmission impairments, concepts of frequency spectrum and bandwidth,

bandwidth efficient modulation techniques.

Basics of computer networks: Protocol hierarchies, design issues for the layers, interfaces and services. Concepts of circuit switching and packet switching, connection-oriented and connectionless services. Reference models—OSI model and TCP/IP reference model. Example networks.

Physical layer: Transmission media—twisted pair, coaxial cable, optical fibre. Wireless transmission—radio, microwave, infrared and millimeter waves, telephone systems, cell phones. RS-232C, SONET, modems.

Data link layer: Services provided to the network layer, framing, error control, flow control. Error detection and correction. Unrestricted simplex protocol, stop-and-wait protocol, sliding window protocols. HDLC.

Network layer: Design issues. Routing algorithms. Congestion control. Internetworking: concepts of subnetwork, bridges, etc. X.25 frame relay.

Group B

Transport layer: Services provided to the upper layers. Elements of transport control protocols—addressing, establishing a connection, releasing a connection, flow control and buffering, crash recovery. Example of simple protocols using services primitives TCP and UDP.

IP: IPv4 datagram, IP addressing, ICMP.

Media access control protocols: Concept of LANs and MANs. ALOHA, slotted ALOHA, CSMA, CSMA/CD. Ethernet, token bus, token ring, FDDI.

ATM: Protocol architecture. ATM logical connections. ATM cells. Transmission of ATM cells. ATM adaptation layer. Traffic and congestion control.

Narrowband and broadband ISDN. Application layer: SNMP, SMTP, FTP, TELNET.

Recommended Books

- .. A. S. Tanenbaum. Computer Networks. Prentice-Hall of India (P) Ltd., New Delhi.
- .. William Stallings. Data and Computer Communications. Prentice-Hall of India (P) Ltd., New Delhi.
- .. Bhavneet Sidhu. Computer Networks. Khanna Book Publishing (P) Ltd., New Delhi.
- .. D. Bertsekas and Robert Gallager. Data Networks. Prentice-Hall of India (P) Ltd., New Delhi.

EC 421

DIGITAL HARDWARE DESIGN

Group A

Basics of digital electronics: Number representation, Boolean algebra, logic minimization, hazard-free design.

Combinatorial and sequential design.

Synchronous and asynchronous circuits.

Memories and PLA.

Finite state machines.

Group B

Processor model: Datapath synthesis and control structures.

Fast adders, multipliers, barrel shifters, etc.

Microprogrammed control unit.

Pipelined and parallel architectures.

Fault-tolerant structures.

Recommended Books

- .. D. J. Gajski. Principles of Digital Design. Prentice-Hall of India (P) Ltd., New Delhi.
- .. Rishabh Anand. Design Electronics. Khanna Books Publishing (P) Ltd., New Delhi.
- .. G. D. Michell. Synthesis of Digital Circuits. McGraw-Hill International, New York.

EC 422

PULSE AND DIGITAL CIRCUITS

(See page 32, subject CP 405)

EC 423

IC DESIGN TECHNIQUES

Group A

Introduction to IC design flow: System specification to final packaging.

MOS transistor, CMOS inverter, static and dynamic logic circuits, latch up problem in CMOS.

Factors for optimization (speed, power, area, etc.)

Timing issues: Clock skew, critical path, logic hazards, etc.

Interconnect: Capacitive, resistive and inductive parasitics.

Basic concepts of partitioning, floor planning, placement, routing and layout. Design rule and circuit extraction, mask making procedure.

Computer aided design, simulation and testing, behavioural modelling and hardware description language.

Group B

Memories and other replicable structures: ROM, PROM, EPROM, E2PROM, Static RAM and dynamic RAM, PLA and PAL.

Basic design methodologies: Full custom and semicustom design. ASIC vs. field programmable devices.

Basic fabrication technology: Bipolar and MOS processing steps and important process parameters.

Importance of semiconductor device modeling. Computer aided design.

Recommended Books

.. N H E West and K Eshraghian. Principles of CMOS VLS Design. Addison Wesley Publishing Co., New York.

.. Rishabh Anand. Digital Integrated Circuits. Khanna Book (P) Ltd., New Delhi.

EC 424

SOLID STATE PHYSICS AND SEMICONDUCTOR DEVICES

Group A

Solid state physics: Atomic structures and quantum mechanical concepts, chemical bonds, solid state structure, band structure, electron and hole concept, intrinsic, extrinsic and compensated semiconductors, carrier concentration, lattice vibrations, mobilities and drift velocities, Fermi level, energy-band diagram.

Carrier transport mechanism: Scattering and drift of electrons and holes, diffusion mechanism, Hall effect, magneto-resistance, quasi-Fermi levels, generation, recombination and injection of carriers, Boltzmann transport equation and scattering rates, transient response, basic governing equations in semiconductor.

P-N junction theory: Physical description of P-N junction, depletion approximation, biasing, transition capacitance, varactor, junction breakdown, space charge effect and diffusion approximation, current-voltage characteristics and temperature dependence, tunneling current, small signal a.c. analysis.

Bipolar junction transistors: BJT action, derivation of current components and gain expressions, breakdown voltages, Ebers-Moll model, hybrid- π equivalent circuit, frequency response of transistors, P-N diode, SCR.

Group B

Fundamentals on technology of semiconductor devices: Unit processes for semiconductor device fabrication, oxidation, diffusion, photolithography and etching, film deposition, device isolation, integrated BJT fabrication processes.

Field effect transistors—JFET and MOSFET: Physical description and theory of JFET, static characteristics, small signal analysis, equivalent circuit, MOS structure, MOS capacitance, flat-band threshold voltages, MOS static characteristics, small signal parameters and equivalent circuit, charge-sheet model, strong, moderate and weak inversion, short-channel effects, hot-carrier effects, scaling laws of MOS transistors, LDD MOSFET, NMOS and CMOS IC technology, CMOS latch-up phenomenon.

Metal semiconductor junctions: Ideal Schottky barrier, current-voltage characteristics, MIS diode, Ohmic contacts, heterojunctions, MESFET.

Photonic devices: Optical absorption in a semiconductor, photovoltaic effect, solar cell, photoconductors, PIN

photodiode, avalanche photodiode, LED, semiconductor lasers

Recommended Books

.. Y S Yang. Microelectronic Devices. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

.. M Shur. Physics of Semiconductor Devices. Prentice-Hall of India (P) Ltd., New Delhi.

.. S M Sze. Physics of Semiconductor Devices. New Age International (P) Ltd., New Delhi.

.. B G Streetman. Solid State Electronic Devices. Prentice-Hall of India (P) Ltd., New Delhi.

EC 425

SOFTWARE ENGINEERING

(See page 37, subject CP 435)

EC 431

SENSORS AND TRANSDUCERS

Group A

Functional description of instrumentation systems. Performance characteristics—static and dynamic, time and frequency responses.

Electrical passive transducers: Hot wire anemometers and associated circuit, LVDT and phase-sensitive detection, variable reluctance type transducers and associated circuits. Capacitive microphone and associated circuits.

Magnetostrictive transducers: Magnetostrictive materials and their application to measurement of force. Hall transducers: principles and applications.

Thermocouple, semiconductor-type temperature sensors.

Piezoelectric transducers: Piezoelectric crystal and its properties, sensitive coefficients, ferroelectric materials, bimorph, charge amplifiers, measurement of force.

Group B

Signal conditioning: Push-pull arrangement and reduction of non-linearity. Linearizing circuits and their applications. Differential amplifiers, instrumentation amplifiers, logarithmic amplifiers. Sources of noise and their reduction, grounding and shielding techniques.

Special transducers: Digital shaft encoders. DC and AC tachogenerators, synchros.

Actuators and servos: DC and AC servomotors, step motors. Elastic transducers: Springs bellows, diaphragms, Bourdon tubes—their characteristics and applications, combination of elastic and electrical transducers. Pneumatic sensors.

Recommended Books

- .. AK Maini. Electronics Simplified, Edition 2017
khannabooks.com Khanna Book Publishing, Delhi.
- .. D Patranabis. Sensors and Transducers. S. Chand & Co. Ltd., New Delhi.
- .. D V SMurthy. Transducers and Instrumentation. Prentice-Hall of India (P) Ltd., New Delhi.

EC 432

INDUSTRIAL INSTRUMENTATION AND COMPUTER CONTROL

Group A

Ultrasonic devices and their applications for sensing and non-destructive testing.

Radio isotopes and their applications. Radio isotope sources, nucleonic detectors, ionization chambers, proportional-Geiger Mueller and scintillation counters. Ionization gauges and nucleonic gauges for measurement of thickness, density, pressure, flow, etc.

Optical transducers: LDR, LEDs, lasers, photodiodes, photomultiplier tubes, IR and UV detectors. Applications to industrial and pollution measurement. Introduction to optical fibre based sensors.

Microwave sensors: Doppler shift technique for velocity measurement.

Sampling techniques for liquids and gases for analysis purposes. Gas analysis, gas chromatography, thermal conductivity method, heat of reaction method. Paramagnetic oxygen meters.

Group B

Humidity and moisture measurement, measurement of viscosity, pH measurement, electrical conductivity measurement.

Spectrochemical analysis: Mass spectrometry, emission spectrometry, absorption spectrometry.

Different types of digital control. Single loop and multiloop, direct digital control, software implementation of multiloop controllers. Sequence control: Programmable logic controllers, relay ladder logic programming.

Supervisory control: Functionality, process optimization, process monitoring. Man-machine interfaces. On-line computer control of processes.

Recommended Books

1. D Patranabis Principles of Industrial Instrumentation. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
2. E B Jones. Instrument Technology—Vol II. Analysis Instruments. Butterworths Scientific Publication, London.
3. J G Bollinger and N A Duffil. Computer Control of

Machines and Processes. Addison-Wesley Publishing Co., New York.

4. J W Webb. Programmable Controllers: Principles and Applications. Merrill Publishing Co., Columbus, USA.

EC 433

BIOMEDICAL ELECTRONICS

Group A

Introduction to human physiology: Body skeleton: Nerve physiology, membrane potential and action potential, function of nerves and of myoneural junction.

Muscle physiology: Functions of skeleton and smooth muscle, cardiac muscle and its rhythmic contraction.

Heart physiology: Dynamics of system, blood flow, arterial pressure, ECG.

Respirations: Mechanism of respiration. Neuro physiology: C N S function of spinal cord and cord reflexes.

Transducers and electrodes: Different types of transducers and their selection for biomedical applications. Electrode theory. Different types of electrodes—hydrogen, calomel, Ag-AgCl, pH, PO₂-PCO₂ electrodes, selection criteria of electrodes.

Group B

Measurement and recording: Cardiovascular measurement: The heart and other cardiovascular systems. Measurement of blood pressure, blood flow, cardiac output and cardiac rate. Electrocardiography, phonocardiography, ballistocardiography, plethysmography, magnet cardiography, computer applications.

Measurement of electrical activities in muscles and brain. Electromyography, electroencephalograph and their interpretation.

Respiratory mechanism. Measurement of gas volume, flow rate, carbon dioxide and oxygen concentration in inhaled air, respiratory controller.

Instrumentation for clinical laboratory: Measurement of pH value of blood, ESR measurements, haemoglobin measurement, oxygen and carbon dioxide concentration in blood, GSR measurement, polarographic measurements, computer applications.

Medical imaging: Ultrasound imaging, radiography magnetic resonance technique and applications.

Biotelemetry: Transmission and reception aspects of biological signals via long distances. Patient care monitoring.

Electronic instruments affecting the human body. Stimulator, defibrillator, pacemaker, diathermy, blood pumps, myoelectric control of paralysed muscles.

Recommended Books

- .. L Cromwell. Biomedical Instrumentation. Prentice-Hall of India (P) Ltd., New Delhi.
- .. RSKhandpur. Handbook of Biomedical Instrumentation. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. E Fox. Human Physiology. McGraw-Hill International.

EC 434

SIGNAL PROCESSING

Group A

Periodic signal analysis: Fourier series, a periodic signal analysis, Fourier transform. Discrete representation of signals, Z-transform, sampling theorem. Effect of quantization. Flow graph.

Digital filter design: IIR filter design based on analog filters, input variance and bilinear transformation approach.

Computer aided design. FIR filter design using windows, computer-aided design. Introduction to multirate filters.

Group B

Computation of the DFT, DCT and WHT. The FFT, mixed radix algorithm, simulation of digital filters. Hardware implementation. Effects of finite register length.

Digital signal processors (Ex TMS-320 family). Discrete random signals. Discrete correlation. Estimation of power spectral density. Application of digital signal processing.

Recommended Books

- .. A V Oppenheim and R W Shaffer. Discrete Time Signal Processing Prentice-Hall of India (P) Ltd., New Delhi.
- .. JC Proakis and D G Maniolas. Digital Signal Processing: Principles, Algorithms and Applications. Prentice-Hall of India (P) Ltd., New Delhi.

EC 435

CONTROL SYSTEMS

Group A

Frequency response techniques: Nyquist criteria—the principle of argument, the Nyquist path; Nyquist criteria for stability, effect of addition of poles and zeros on the shape of Nyquist locus.

Relative stability: Determination of gain margin and phase margin from Nyquist and Bode plots. Constant M and N loci in the G-plane; Nichol's charts. Application of Nichol's charts.

State space techniques: State variable analysis of dynamical systems, canonical forms, controllability and observability, stability. Introduction to optimal control, quadratic performance index and regulator problems.

Group B

Compensation techniques: Specifications of control systems in time and frequency domains. Series compensations—lag, lead and lag-lead design using Bode plots. Linear system design by state variable feedback.

Discrete data systems: Z-transforms and inverse Z-transforms, stability-unit circle, bilinear transform, Jury's stability criterion. Difference equations. Types of digital control of plants.

Nonlinear elements and systems: Phase plane and describing function methods. Stability analysis and Liapunov's method.

Recommended Books

- .. I J Nagrath and M Gopal. Control System Engineering. New Age International (P) Ltd., New Delhi.
- .. M Gopal. Modern Control Theory. Prentice-Hall of India (P) Ltd., New Delhi.
- .. A Ambikapathy. Control Engineering. Khanna Books Publishing Co. (P) Ltd., New Delhi.

The First Tool That Brought Civilization

The history of mechanical engineering begins from the time when the oldest man started making stone tools. The gradual development of elementary mechanical parts in metals followed over many centuries. Archimedes (287-212 BC) invented a water screw and a technique for moving great weights by a small force. The concept of perpetual motion was clearly formulated by Bhaskara in his *Siddhanta Shiramir*. The Chinese converted rotary motion into reciprocating motion for a trip hammer. Hero of Alexandria invented a steam turbine in the first century BC and called it an aeolipile. Leonardo da Vinci invented, amongst other things, a centrifugal pump. It is evident, therefore, that from ancient time, application of mechanisms or simple machines were known to some civilizations.

The Second Wave

The invention of an atmospheric steam engine by Thomas Newcomen in 1712 and the steam engine by James Watt in 1768 were the most significant contributions which brought about the Industrial Revolution. By 1786, Watt's engines were driving paper mills, corn mills and cotton spinning mills and were put in operation in mining, steel and other industries. Engines were also used to propel boats and rail road carriages (1825). An immense source of power was then at the disposal of man at a place and time suited to him.

Evolution of Mechanical Engineering

Curiously enough, any book on mechanical vibration is found not to illustrate only absolute mechanical systems; the books rather analyse any system irrespective of mechanical, electrical, acoustic and even heat dissipation or energy transfer in general. The implication remains rather mechanics of vibration and it has nothing to do with mechanical engineering.

Mechanical Engineering

It is a discipline in which mathematics and science are blended with experience and judgement for the production of useful things. It strives to utilize economically the materials and forces of nature for the production of serviceable goods. Formal training of a mechanical engineer includes a knowledge of mathematics, physics, thermodynamics, mechanics of materials and fluids, statics, dynamics and chemistry, with specialisation in metal cutting and machine tools, manufacturing systems, etc.

It was mainly Euler who first generalised the aspects of statics and dynamics in classical mechanics and distinctively brought the concepts of *kinematics* and *kinetics*. In the former, the geometry of motion (that is, the effect) without any regard to the force (that is, the cause) was analysed and the implements which offered the desired path of motion were termed as **mechanisms**. These were the set of systems providing the needed transfer and transformation of motion only and such systems were being gradually called **mechanical systems**.

The impact of the lexicon 'mechanism' was so great in the classical science that every observation in nature—be it micro-, macro-, or mega-systems—was used to be explained in terms of mechanical models and the world of science became almost mechanistic in every aspect. The magnanimity of the word is revealed even in *quantum mechanics* and *mechanisms of chemical reactions*.

On the other hand, the branch *kinetics* was evolved parallelly to offer a joint transfer and transformation of motion and energy, where the force causing the motion was given due regard, the nature of the force being of any kind—constant, cyclic or even intermittently varying. The devices offering such transfer and transformation of energy and motion were subsequently termed as **engines** or

simply **machines**, implying extended mechanical systems. To round up the understanding of any such system the help of other branches of sciences like mathematics, physics, thermodynamics, mechanics of materials and fluids was resorted to different extent and to such a dimension that gave rise to a separate discipline now called **Mechanical Engineering**.

Seeking for a Separate

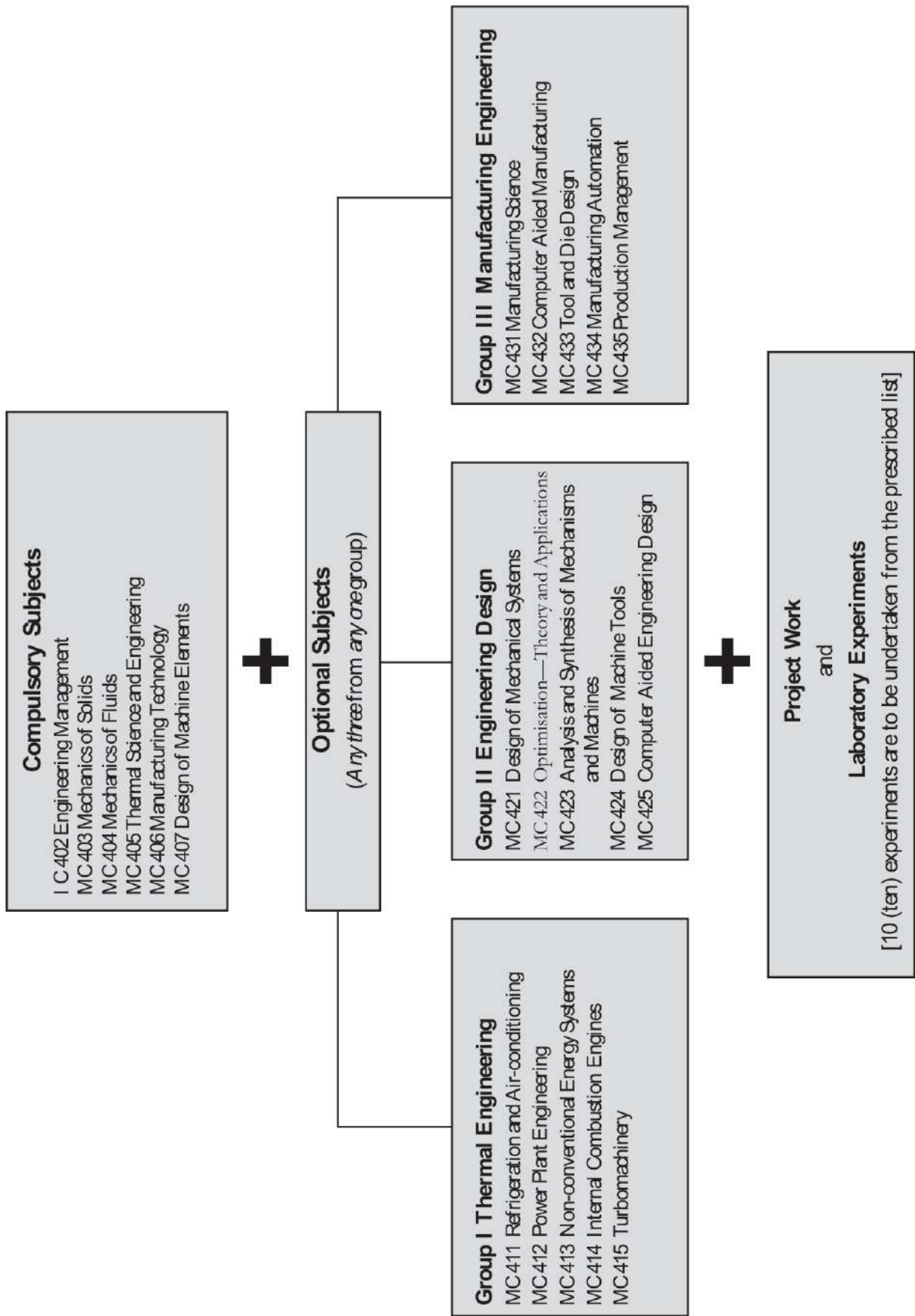
Entity—Institutionalization

On the refusal of membership to George Stephenson, inventor of the steam locomotive, by The Institution of Civil Engineers, a distinct group of engineers and mechanics engaged in manufacturing and railway operations, segregated themselves as 'mechanical engineers'. Subsequently, persons engaged in the production of bicycles and motor cars also joined the group. However, certification of mechanical engineers through academic evaluation started only in early twentieth century.

Indian Scene

The embryo of mechanical engineering as a hybrid course of electrical and mechanical engineering was planted by Late Prof. King in the Benaras Hindu University. However, during the national movement the National Council of Education, Bengal was established in 1906 with Sri Aurobindo as its first Principal. Subsequently it became one of the pioneering institutions in India to encourage the study of total mechanical engineering led by pioneers like Late Prof H C Dasgupta and Late Prof S C Bhattacharyya. Almost concurrently the programme was started in Guindy and Poona. Now, practically all engineering colleges and polytechnics conduct courses in mechanical engineering to cater for the needs of manufacturing industries, the power sector, corporations, private and government R & D departments, teaching institutions, etc. Mechanical engineers are also self-employed as consultants or entrepreneurs.

MECHANICAL ENGINEERING



MECHANICAL ENGINEERING

IC 402

ENGINEERING MANAGEMENT

(See page 13, subject IC 402)

MC 403

MECHANICS OF SOLIDS

Group A

Review of free body diagrams; Analysis of deformation under axial loading. Simple shear and pressure.

Statically determinate and indeterminate cases. Forces and moments transmitted by simple beams.

Mechanics of deformable solids, stress and strain, transformation of stress and strain, Mohr circle diagram, equilibrium equations and compatibility conditions.

Material properties and their testing: Elastic, inelastic, plastic and viscoelastic material behaviour. Fatigue and creep. Concepts of ductility, hardness, toughness and their quantification. Tensile and impact tests.

Group B

Stress-strain-temperature relations. Generalised Hooke's law and thermal strains.

Equations of elasticity. Solutions of thin and thick cylinders and rotating disks.

Stresses in beams. Torsion of circular shafts and thin walled sections. Deflection of helical springs.

Yield criteria, energy methods, basic elasticity equations.

Recommended Books

- .. D S Bedi. Strength of Materials. Khanna Book Publishing Co. (P) Ltd., New Delhi.
- .. S P Timoshenko. Strength of Materials—Vols 1 and 2. CBS Publishers & Distributors, New Delhi.
- .. SH Crandall, N C Dahl and T J Lardner. An Introduction to Mechanics of Solids. McGraw-Hill International.
- .. G K Lal, et al. Mechanical Sciences. The Institution of Engineers (India) Textbook Series, Narosa Publishing House, New Delhi.

MC 404

MECHANICS OF FLUIDS

Group A

Properties and classification of fluids. Fluid statics, buoyancy. Scalar and vector fields, Reynold transport theorem.

Continuity and momentum equations, momentum theorem, Bernoulli's equation and their applications.

Constitutive relation for a Newtonian fluid. Navier-Stokes equations, exact solutions for flow between parallel plates, rotating cylinders, Couette flow and Poiseuille flow.

Application of viscous flows through pipes; Correlation of friction factor.

Laminar boundary layer, boundary layer equations, Blasius solution over a flat plate, wall shear stress, boundary layer thickness, boundary layer control.

Group B

Separation; momentum integral method.

Turbulent flow; mixing length models; Skin friction coefficient in a turbulent boundary layer.

Compressibility flow; Nozzles and diffusers; Shocks; Effect of friction and heat transfer.

Potential flows.

Experimental methods for flow and velocity measurements.

Recommended Books

- .. I H Shames. Mechanics of Fluids. McGraw-Hill International.
- .. SK Som and G Biswas. Introduction to Fluid Mechanics. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. Sadhu Singh. Fluid Mechanics. Khanna Books (P) Ltd., New Delhi.

MC 405

THERMAL SCIENCE AND ENGINEERING

Group A

System, property, work and heat interactions, zeroth law, first law of thermodynamics, application of first law to closed systems and flow processes.

Thermodynamic properties of fluids.

Second law of thermodynamics, Carnot cycle, temperature scale, Clausius inequality, entropy increase, availability.

Thermodynamic property relations. Clapeyron equation.

Power and refrigeration cycles. Operating principles and essential components of vapour power cycles. IC engines and gas turbines.

Thermodynamics of mixtures, psychrometry.

Group B

Conduction: One-dimensional steady and unsteady state problems, fins, multidimensional problems.

Convection: External flows, boundary layer flow on a heated flat plate.

Thermally and hydro-dynamically fully developed flow through a pipe, turbulence flow, Dittus Boelter's and Sieder state correlation.

Natural convection, condensation and boiling.

Heat exchangers, LMTD and e-NTU method.

Radiation: Fundamental concepts, black body radiation, surface emission, surface properties, Kirchhoff's law, view factor, black body radiation exchange.

Recommended Books

- .. Y V C Rao. An Introduction to Thermodynamics. New Age International (P) Ltd., New Delhi.
- .. PK Nag. Basic and Applied Thermodynamics. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. J P Holman. Heat Transfer. McGraw-Hill International.
- .. S P Sukhatme. A Text Book on Heat Transfer. Orient Longman Ltd., New Delhi.
- .. Bedi, Sharma. Thermodynamics. Khanna Publishing Co. Ltd., New Delhi.

MC 406

MANUFACTURING TECHNOLOGY

Group A

Introduction. Manufacturing cycle. Manufacturing processes and their selection. Engineering materials and their selection.

Casting: Patterns, gating system design, riser design, product design, defects, inspection techniques. Other casting processes: investment casting, die casting, centrifugal casting and continuous casting. Basic design considerations in casting.

Metal forming: Plastic deformation, hot and cold working. Forming operations—rolling, extrusion, drawing processes, sheet metal operations, load estimations for homogeneous deformation. Sheet metal die design. High velocity forming processes.

Heat treatment processes.

Processing of plastics: Extrusion, injection moulding, blow moulding, rational moulding, thermo-forming and compression moulding. Basic design considerations, rapid prototyping, stereolithography technique.

Powder metallurgy processing: Production of metal powders, compaction and sintering processes.

Group B

Metal cutting: Tool materials, tool geometry and nomenclature in ASA, ORS and NRS, cutting fluids, single and multipoint cutting operations, production of gears and screw

threads, grinding and finishing processes, specification of grinding wheels.

Machine tools: Primary and secondary drives, guideway and slideways, structure. Introduction to NC, CNC and DNC machining.

New machining methods: Process capabilities and limitations of AJM, USM, WJM, ECM, ECG, EDM, EBM and LBM processes.

Joining processes: Fusion welding processes, heat affected zone, testing of welded joints, solid state welding processes, brazing and soldering. Basic design considerations in welding. Process selection. Adhesive bonding. Mechanical fastening processes.

Recommended Books

- .. SK Alpakjian. Manufacturing Engineering and Technology. Addison-Wesley (India).
- .. P N Rao. Manufacturing Technology. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. E P DeGarmo, J T Black and R Kosher. Materials and Processes in Manufacturing. Macmillan International.
- .. G K Lal and S K Choudhary. Fundamentals of Manufacturing Processes. Narosa Publishing House, New Delhi.
- .. P K Mishra. Nonconventional Machining. Narosa Publishing House, New Delhi.

MC 407

DESIGN OF MACHINE ELEMENTS

Group A

Mechanical systems and elements, overall design considerations, safety, ecological and societal considerations in design. Codes for design—Bureau of Indian Standards (BIS) codes, design data handbook. Load, stress and critical sections in machine parts.

Materials, stress-strain curves of ductile and brittle materials, cast iron, steel, non-ferrous alloys and plastics, hardness and surface properties of materials, material strength, factor of safety and allowable stress. Review of axial, bending, shear and torsional loading on machine components, combined loading, two- and three-dimensional Mohr's circle. Stresses in curved beams, thick and thin shells under pressure.

Deflection and stability, beam deflection and column buckling, Euler's formula and Johnson's formula. Failures theories—maximum normal stress theory, maximum shear stress theory, and maximum distortion energy theory. Application to components made of brittle and ductile materials, stress concentration factor.

Cyclic loading and fatigue failures: Reverse bending, axial

and torsion loadings, effect of stress concentration, fatigue life prediction—Miner's rule, effect of surface treatments (shot-peening, surface hardening) on fatigue life of components.

Design of threaded fasteners and power screws, thread forms and threaded fastener types and materials, power screws, bolt tightening and initial tension, static and fatigue loading in bolts, bending and axial loading on a group of bolts.

Rivets and welding: Loading, bending, direct shear, axial and bending.

Group B

Design of springs: Spring materials, helical compression and extension springs, design for fatigue, loading, leaf springs. Design of sliding bearings, bearing materials, fluid viscosity, hydrodynamic lubrication, Petroff's equation, Raimondi and Boyd chart. Heat dissipation.

Rolling elements bearings: Types, catalogue information (Timken and SKF bearings), bearing life radial and thrust loads. Selection of bearings. Spur, helical and worm gears, gear tooth profile, gear geometry, module, contact ratio, gear train, gear tooth bending strength, gear tooth surface fatigue analysis, gear material.

Design of shafts, keys, pins and splines, shaft couplings. Cotter and pin joints, pipe joints, gaskets, seal and packing, cylinder joints, flanged joints.

Clutches and brakes: Single and multiple plate clutch, constant wear and constant pressure theories for plate clutches, materials, shoe drum brakes, internal and external shoe brakes.

Power transmission elements: Belts and chain drives, design of flat and V-belts.

Recommended Books

- .. Sadhu Singh. Machine Design. Khanna Book (P) Ltd., Delhi.
- .. JE Shigley and L D Mitchell. Mechanical Engineering Design. McGraw Hill International.
- .. R S Khurmi and J K Gupta. A Text Book of Machine Design. S Chand & Co. Ltd., New Delhi.

MC 411

REFRIGERATION AND AIRCONDITIONING

Group A

Introduction to refrigeration and airconditioning, methods of refrigeration—conventional and nonconventional, unit of refrigeration, COP and refrigeration efficiency.

Air refrigeration. Carnot, Bell Coleman, Brayton cycles, simple and bootstrap aircraft refrigeration systems.

Mechanical refrigeration. Carnot vapour refrigeration compression cycle, simple vapour compression cycle. Effect of sub-cooling and superheating on cycle performance, actual vapour

compression cycle, multistage and cascade refrigeration, industrial refrigeration systems.

Vapour absorption refrigeration: Working principle, COP comparison between vapour absorption and vapour compression refrigeration systems, actual ammonia vapour refrigeration systems, Lithium bromide water absorption system, electrolux refrigeration system.

Group B

Steam jet refrigeration system: Principle and applications, performance, actual steam jet refrigeration. Vortex and pulse tube refrigeration, theory and operation.

Thermoelectric refrigeration: Thermoelectric elements, working principle and COP refrigerants, desirable properties of refrigerants, primary and secondary refrigerants, various refrigerants and their properties, alternatives to the chloro fluorocarbons.

Air-conditioning: Psychrometry, psychrometry chart and various psychrometric processes, comfort and industrial airconditioning, effective temperature and comfort chart, unitary and central airconditioning systems.

Cooling and heating load calculations, design conditions, sensible and latent heat loads, sensible heat ratio, structural, electrical, infiltration and ventilation heat gains, occupancy heat gains, apparatus dew point, bypass and contact factors.

Recommended Books

- .. C P Arora Refrigeration and Airconditioning, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. Sadhu Singh. Refrigeration and Airconditioning. Khanna Book Publishing (P) Ltd., New Delhi.

MC 412

POWER PLANT ENGINEERING

Group A

Thermal power stations. Main components and working of power stations, thermodynamics cycles, fuel handling, combustion and combustion equipment, problem of ash disposal, circulating water schemes and supply of makeup water. Choice of pressure of steam generation and steam temperature, selection of appropriate vacuum economiser, air pre-heater, feedwater heaters and dust collection. Characteristics of turbo alternators, steam power plant, heat balance and efficiency.

Boilers and steam generation, general classification, fire tube and water tube boilers, natural circulation and forced circulation boilers, high pressure, high temperature boilers, supercritical pressure boilers, boiler mounting and accessories, feed pumps, economisers, superheaters, air preheaters, boiler furnaces, heat generation rates, water walls.

Gas fired and fuel fired oil furnaces, pulverised fuel fired furnaces, burners for gas fired, fuel oil-fired and pulverised fuel

fired furnaces, grate fired furnaces for solid fuels, feedwater pumps and pipings, boiler settings, estimation of air quantity requirement and draught systems, ID and FD fans.

Diesel power plants: Diesel engine performance and operation, plant layout, log sheets, selections of engine size.

Gas turbine plants: Plant layout, methods of improving output and performance fuel and fuel systems, methods of testing, open and closed cycle plants, operating characteristics.

Group B

Combined working of power plants: Advantages of combined working of different types of power plants, need for co-ordination of types of power plants in power systems, base load stations and peak load stations.

Hydroelectric plants: Penstocks, water turbines, specific speed, turbine governors, hydroplant auxiliaries, plant layout, automatic and remote control of hydroplants, pumped projects, cost of hydroelectric project.

Nuclear power plants: Elements of nuclear power plants, nuclear reactor fuel moderators, coolants, control.

Major electrical equipment in power plants: Generator and exciters, power and unit transformers, circuit breakers, protective equipment, control board equipment, elements of instrumentation.

Power station auxiliaries. Alternate power sources. Solar power, geothermal, tidal and wind power.

Recommended Books

- .. P K Nag. Power Plant Engineering (Steam and Nuclear). Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. B G A Skrotzki and W A Popat. Power Plant Engineering. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. Ashish Chandra. Non-conventional Energy Sources. khannabooks.com, Delhi.

MC 413

NON-CONVENTIONAL ENERGY SYSTEMS

Group A

Introduction to non-conventional sources—Solar, biogas, wind, tidal, geothermal.

Basic bio-conversion mechanism; source of waste; simple digester; composition and calorific values of biogas.

Wind and tidal energy generation; Special characteristics; Turbine parameters and optimum operation; Electrical power generation from wind/ tidal energy.

Energy from the sun: Techniques of collection; Storage and utilisation; Types of solar collectors; Selective surfaces; Solar thermal processes; Heating; Cooling; Drying; Power generation, etc.

Group B

Direct energy conversion methods: Photoelectric, thermoelectric, thermoionic, MHD (magnetohydrodynamics) and electro-chemical devices; Solar cells.

Photovoltaics, Amorphous semiconductors; Limitations of photovoltaics efficiency; Fuel cells; Peak load demands; Developments in fuel cells and applications.

Ocean thermal energy conversion; Geothermal energy hot springs and steam injection; Power plant based on OTEC and geothermal springs.

Fusion energy: Control through fusion of hydrogen and helium. Energy release rates—present status and problems. Future possibilities.

Integrated energy packages using solar, biomass, wind, etc. Comparative study of non-conventional energy sources; Cost considerations and economics.

Recommended Books

- .. S P Sukhatme. Solar Energy: Principles of Thermal Collection and Storage. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. Ashish Chandra. Non-conventional Energy Sources. Khanna Books, Delhi.
- .. M Ali Kettani. Direct Energy Conversions. Addison Wesley Publishing Co., New York.

MC 414

INTERNAL COMBUSTION ENGINES

Group A

Classification of engines according to fuels, cycle of operation and number of strokes, construction details, valve arrangements, application of IC engines, review of air standard cycles, deviation of actual cycles from fuel air cycles, various influencing factors. Review of fuels for IC engines with particular

reference to velocity, ignition quality and knock rating, variable compression ratio engines.

Air-fuel ratios and mixture requirements of SI engines, stoichiometric fuel air ratio, lean and rich mixture operation, optimum conditions, carburetors—principle, types and venturi, fuel orifice sizes, charge stratification and distribution.

Fuel-air requirement in CI engines. Methods of fuel oil distribution and injection. Types of injector systems in SI and CI engines. Flame front and normal combustion. Detonation in SI and knocking CI engines. Factors influencing detonation and knock. Comparative analysis. Ignition systems in SI and CI engines.

Group B

Engine friction and lubrication: Effect of engine variables, total engine friction, requirements of lubricants and lubricating systems.

Cooling systems: Gas temperature variation, heat transfer rates, piston and cylinder temperature, heat rejected to coolant, air and water cooling systems and components.

Two-stroke engines: Special features, scavenging systems.

Supercharging: Objects, effects on engine performance, supercharging limits, methods of supercharging with special emphasis on turbochargers.

Engine testing and performance: Various performance parameters and their measurements.

Air pollution from engine exhaust, its measurement and control, principle constituents of engine, emission methods of control, modification of conventional engines, dual fuel and multifuel engines, stratified charged engines, sterlings engines, Wankel rotary combustion engine.

Recommended Books

- .. V Ganeshan. Internal Combustion Engines. Tata McGraw-Hill Publishing Co., Ltd., New Delhi.
- .. M L Mathur and RP Sharma. Internal Combustion Engines. Dhanpat Rai & Sons, Delhi.
- .. H. N. Gupta. Fundamentals of Internal Combustion Engines. Prentice-Hall of India(P) Ltd., New Delhi.

MC 415

TURBOMACHINERY

Group A

Positive displacement and turbomachines. Basic principles of rotodynamic machines. Efficiency of turbomachines.

Flow through nozzles and blade passages: Steady flow through nozzles, isentropic flow; Effect of friction in flow passages; Converging-diverging nozzles; Flow of wet steam through nozzles; Diffusers.

Steam and gas turbines. Pressure and velocity compounding; Velocity diagrams; Degree of reaction; Utilisation factor; Reaction blading; Analysis of flow through turbomachines; Energy equation; Momentum equation.

Fluid dynamic consideration: Theoretically obtainable work head; Profile losses. Clearance and leakage losses. Windage losses. Partial admission losses. Flow deviation, Diffuser performance. Design of blade passages. Cavitation in turbomachines.

Group B

Centrifugal compressors: Description and operation, energy transfer and relations, losses, adiabatic efficiency, effect of compressibility, performance characteristics, pressure coefficient, slip factor, surging, surge lines and stall line.

Axial compressor: Introduction, stage characteristics, blade efficiency, design coefficients, blade loading, cascade characteristics, three-dimensional flow considerations, supersonic axial flow compressor, performance characteristics.

Wind turbines: Power, energy and torque of wind turbines, coefficient of performance, energy production and capacity factor, turbine shaft power, torque at variable speeds.

Hydraulic turbomachines: Hydraulic turbines (Pelton wheel and Kaplan turbines), centrifugal and axial flow pumps, characteristics of hydraulic turbomachines.

Fans: Classification, fan laws.

Power transmitting turbomachines; Hydraulic coupling; Torque converters.

Recommended Books

- .. H Cohen, G F C Rogers and H H H Saravanamutto. Gas Turbine Theory. ELBS-Longman.
- .. SM Yahya. Turbines, Compressors and Fans. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. V Kadambi and M Prasad. An Introduction to Energy Conversion. Vol. III-Turbomachinery. New Age International (P) Ltd., Delhi.

MC 421

DESIGN OF MECHANICAL SYSTEMS

Group A

The essential inputs to a design engineer. Stages in design. Creative and evolutionary design. Problem formulation. Preliminary design and analysis.

Conceptual design: Alternative designs, feasibility analysis and design space, best design constraints, system integration, rational design.

Design process and design cycle. Design morphology.

Design databases and design standards.

Selection of materials and processes. Accuracy, surface finish, tolerances, statistical nature of loads, part dimensions. Probabilistic design, factor of safety.

Detailed design of simple systems involving pressure vessels, fasteners, pins and welds.

Group B

Optimal design of machine elements and systems. Minimum weight and minimum cost design rigidity and strength.

Reliability of systems, failure rate and component life, MTBF, reliability considerations in design.

Static and dynamic analysis of engineering systems involving shafts, linkages, couplers, transmission devices, toothed elements, etc.

Recommended Books

- .. G E Dieter. Engineering Design. McGraw-Hill
- .. JE Shigley and L D Mitchell. Mechanical Engineering Design. McGraw-Hill International.

.. L S Srinath. Reliability Engineering. Affiliated East West Press(P) Ltd., New Delhi.

MC 422

OPTIMISATION—THEORY AND APPLICATIONS

Group A

Introduction to optimisation: Historical development. Engineering applications. Statement of an optimisation problem, classification and formulation of optimisation problems, optimisation techniques.

Classical optimisation methods: Single variable optimisation, multivariable optimisation with and without constraints.

Linear programming: Standard form of a linear programming problem (LPP), geometry of LPPs, related theorems, linear simultaneous equations, pivotal reduction, simplex method, revised simplex method, duality, decomposition, transportation and assignment problems.

Nonlinear programming (unconstrained): Uni-modal function, exhaustive search, bi-section and golden section methods, interpolation methods, random search methods, univariate method, gradient of a function, conjugate gradient, quasi-Newton and variable metric methods.

Group B

Nonlinear programming (constrained): Complex method, cutting plane method, method of feasible directions, transformation techniques, penalty function methods, convergence checks.

Geometric programming: Introduction to geometric programming, polynomial, unconstrained and constrained problems.

Dynamic programming: Introduction to dynamic programming, multistage decision processes, computational procedures, calculus and tabular methods.

Recommended Books

- .. S S Rao. Optimisation—Theory and Applications. New Age International (P) Ltd., New Delhi.
- .. K Dev. Optimisation for Engineering Design: Algorithm and Examples. Prentice-Hall of India (P) Ltd., New Delhi.
- .. N G R Iyengar and SK Gupta. Structural Optimisation. Affiliated East-West Press (P) Ltd., New Delhi.
- .. JK Sharma. Operations Research. Macmillan India Ltd., New Delhi.

MC 423

ANALYSIS AND SYNTHESIS OF MECHANISMS AND MACHINES

Group A

Mechanisms and machines, kinematic pair, elements, chains

and inversions, degree of freedom, movability, Grubler's criterion, four-link mechanisms, Grashof's criteria.

Kinematic analysis, instantaneous centres, Kennedy theorem, velocity analysis using velocity difference and instantaneous centres, acceleration analysis, velocity and acceleration images.

Kinematic synthesis, graphical method using inversion and overlay, three-point synthesis problems, motion, path and function generation. Freudenstein's method of three point synthesis of four link mechanisms.

Dynamic force analysis of four-bar and slider crank mechanisms, turning moment and flywheel analysis.

Types of governors, characteristics of centrifugal governors, stability control of speed hunting of governors.

Group B

Balancing of rotating masses: Two balancing masses in two planes for complete dynamic balance.

Determination of balancing masses, balancing of rotors, balancing of internal combustion engines, balancing of multicylinder inline engines, V-twin cylinder, multi-row W-engine and radial engine. Lanchester technique for balancing internal combustion engines with rotating eccentric weights.

Types of cam followers, selection of motion, displacement diagrams, cam profile determination.

Gears and gear trains, fundamental law of gearing, involute tooth profile, undercutting and interference. Minimum number of teeth, types of gears, simple, compound and epicyclic gear trains.

Gyroscopic action in machines, simple precession of a symmetrical rotating body.

Recommended Books

- .. A Ghosh and A K Mallik. Theory of Mechanisms and Machines Affiliated East-West Press (P) Ltd., New Delhi.
- .. JS Rao and RV Dukkipati. Mechanism and Machine Theory. New Age International (P) Ltd., New Delhi.
- .. J E Shigley and J J Vicker (Jr). Theory of Machines and Mechanisms. McGraw-Hill International.

MC 424

DESIGN OF MACHINE TOOLS

Group A

Conceptualisation of mechanical systems for prescribed scheme; Layout of machine tool elements; Introduction to machine tool drives and mechanisms; General principles of machine tool design.

Design of drive systems; Regulation of speed and feed; Kinematic structure of machine tool gear box; Hydraulic, mechanical and electrical speed regulation.

Design of machine tool structures. Material selection; Welded vs. cast structure; Static and dynamic stiffness; Choice of element sections and their design.

Group B

Analysis of spindles, bearings, slides and guides.

Control systems for machine tools.

Dynamics of machine tools: Machine tools as a closed loop system. Dynamic stability. Forced vibration and chatter in machine tools.

Concept of modular design; Concepts of aesthetic and ergonomics applied to machine tools; Acceptance tests and standardisation of machine tools.

Recommended Books

- .. N K Mehta. Machine Tool Design. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. G C Sen and A Bhattacharya Principles of Machine Tools. New Central Book Agency, Kolkata.
- .. SK Basu. Machine Tool Design. Oxford & IBH Publishing Co (P) Ltd., New Delhi.

MC 425

COMPUTER AIDED ENGINEERING DESIGN

Group A

Computer aided design of engineering systems. Applications in modelling, analysis, design and manufacturing.

Computer graphics, raster graphics and interactivity, pixels and graphic display in computers, windows and view-ports, lines and circles, graphic data storage and manipulation, hardware display, input and output devices.

Geometric transformations—two, three—dimensional and homogeneous transformations, rotation, translation, mirror, perspective, projections, etc.

Computer aided drafting. Introduction to Auto CAD—use of menus and icons, two-dimensional drawings using auto CAD lines, circles, tangents, simple machine drawings, dimensioning, blocks and layers, editing and adding text to a drawing.

Advanced auto CAD—three—dimensional drawings. Curves, surfaces and solid models, customizing Auto CAD, auto LISP.

Group B

Design of curves—PC, Bezier and B-spline curves, normal, tangent, curvature and torsion of curves. Blending of two curves.

Design of surfaces, tangent and normal planes. Curvature and twist, surface patches—PC, Bezier and B-spline, ruled and developable surfaces, swept and revolved surfaces.

Solid modeling—wire frame, constructive solid geometry (CSG) and boundary representation (B-rep); parametric instancing. Cell decomposition, spatial occupancy enumeration, generalized sweep.

Mass property calculations—curve length, surface area,

volume, centroid, mass, moment, etc.

Finite element analysis: Fundamentals of finite element analysis; discretization, mesh generation, pre and post-processing and simple applications.

Recommended Books

- .. I Zeid. CAD/ CAM: Theory and Practice. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. G Omura Mastering Auto CAD 14. BPB Publications, New Delhi.
- .. S S Rao. Finite Element Analysis. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

MC 431

MANUFACTURING SCIENCE

Group A

Deformation of metals, stress-strain curves, temperature and strain rate effects, ductility and toughness, plane-strain deformation, mechanism of plastic deformation, control of material properties—alloying and heat treatment.

Sand casting: Pattern materials and allowances, moulding materials, properties of moulding sand, effects of moulding ingredients on mould properties, estimation of pouring time, mechanism of solidification, rate of solidification in an insulating mould, riser design and placement, residual stresses.

Elements of plasticity—yield criteria and flow rule, plastic instability. Analysis of forming processes—forging, rolling, extrusion, wire and strip drawing, using slab method, deep drawing, blanking and piercing. Lubrication and friction in metal forming.

Group B

Metal cutting: Mechanics of orthogonal cutting, chip formation in turning, shaping, planing, milling and drilling, evaluation of surface roughness in machining, heat generation, estimation of average tool temperature, tool wear mechanism and tool life testing, variables affecting tool life machining economics—estimation of cost and optimum cutting conditions.

Metal grinding: Basic mechanics of grinding process, forces and specific energy, grinding temperature—heat sources and estimation of average temperature, wheel wear mechanism, estimation of surface roughness.

Non-conventional machining: Classification of processes, mechanism of material removal and effects of process parameters in AJM, USM, ECM, EDM, LBM, EBM and PAM.

Welding and allied processes: Bonding process in welding, principles of solid-state welding, fusion welding, soldering and brazing, effects of process parameters, metallurgy of welding stress distribution and heat affected zone.

Recommended Books

- .. A Ghosh and A K Mallik. Manufacturing Science. Affiliated East-West Press (P) Ltd., New Delhi.
- .. J A Schey. Introduction to Manufacturing Processes. McGraw-Hill International.
- .. G K Lal. Introduction to Machining Science. New Age International (P) Ltd., New Delhi.
- .. P K Mishra. Non-conventional Machining. Narosa Publishing House, New Delhi.

MC 432

COMPUTER AIDED MANUFACTURING

Group A

Basic definitions of manufacturing systems: Definitions, design, planning and control.

Part design and CAD: Engineering design, design drafting and its interpretation, inspection and measurement. A brief history of CAD, CAD hardware and software. Fundamentals of geometric modeling, CAD data exchange.

Process engineering: Experience-based planning, process capability analysis, basic machining and other manufacturing process calculations, process optimisation.

Hard automation: Introduction to automated manufacturing, fixed automated manufacturing systems, workpiece handling hardware for automation and economics of automation.

Programmable logic controllers: Function of controllers, control devices, programmable logic controllers.

Data communication and local area networks in manufacturing: Fundamentals of data communication and local area networks.

Group B

Fundamentals of numerical control: Historical developments and principles of NC, classification of NC, NC part programming, manual and computer-assisted part programming.

Introduction to industrial robots: Power sources, actuators and transducers. Robot applications. Economic considerations of robotic systems.

Group technology: Introduction, coding and classification, benefits of group technology.

Process planning: Introduction, manual process planning, computer aided process planning, variant and generative approaches, simple examples.

Introduction to concurrent engineering, FMS and CIM.

Recommended Books

- .. P N Rao, N K Tiwari and T K Kundra. Computer Aided Manufacturing. Tata McGraw-Hill Publishing Co. Ltd., New

Delhi.

- .. S K Vajpayee. Principles of Computer Integrated Manufacturing. Prentice-Hall of India (P) Ltd., New Delhi.

MC 433

TOOL AND DIE DESIGN

Group A

Influence of tools and dies on quality, productivity and environment, tool design methods and procedures, tool making practices, tooling materials and treatment.

Jigs and fixtures. Basic principles of locating and clamping, development of fixture using locating, clamping, indexing tool setting elements, force analysis, standardisation of elements, illustrative examples of machining, welding, assembly and inspection fixtures.

Design of cutting tools and special tools (form cutters and broachers), tooling for CNC, introduction to modular fixtures and tools.

Group B

Die design: Design of sheet metal blanking, piercing, bending and deep drawing dies. Progressive die design.

Mould design. Introduction to die casting and injection mould design. General mould construction. Design of ejection, feed and cooling systems. Parting surface design. Side cores and side cavities. Product design for die casting and injection molding.

Cost estimation and cost benefit analysis.

Recommended Books

- .. C Donaldson, G H LeCain and V C Gould. Tool Design. Tata McGraw Hill Publishing Co. Ltd., New Delhi.
- .. ASTM E (Ed. F W Wilson). Fundamentals of Tool Design. Prentice Hall of India (P) Ltd., New Delhi.
- .. P N Rao. Manufacturing Technology—Foundry, Forming and Welding. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

MC 434

MANUFACTURING AUTOMATION

Group A

Definition of automation, reasons for automating, pros and cons of automation.

Fundamentals of manufacturing and automation: Manufacturing operations and automation strategies, production economics.

High volume production systems: Detroit type automation, analysis of automated flow lines, assembly and line balancing, automated assembly systems.

Numerical control production systems: CNC, DNC and adaptive control.

Group B

Industrial robots: Robotics technology, robot applications.

Material handling and storage: Automated materials handling, automated storage and retrieval systems.

Flexible manufacturing systems (FMS): FMS workstations, material handling and storage systems, computer control systems, planning the FMS, analysis methods for FMS, applications and benefits.

Automated inspection and testing: Inspection and testing, statistical quality control, automated inspection principles and methods, sensor technologies for automated inspection, coordinate measuring machines, other contact inspection methods, machine vision and other optical inspection methods, and non-contact inspection methods.

Recommended Books

- .. M P Groover. Automation, Production Systems and Computer Integrated Manufacturing Prentice Hall of India (P) Ltd., New Delhi.
- .. P N Rao, N K Tiwari and T K Kundra. Computer Aided Manufacturing. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

MC 435

PRODUCTION MANAGEMENT

Group A

Introduction. Concept of management, concept of a system, production system, production functions.

Organisation fundamentals. Guidelines for good practice, organisation structures, organisation charts, span of control, number of levels, number of executives, management functions.

Production economics: Kinds of costs, evaluation of capital investments. Capital budgeting, break-even analysis, make or buy decisions, evaluation of alternatives, discounted cash flow, equivalent comparison methods, depreciation.

Aggregate planning. Planning time horizons, inputs to aggregate planning systems, single and multistage aggregate planning systems, decision processes for aggregate planning—graphical method, linear decision rule, and linear programming method.

Demand management. Timespan for forecasts, forecasting

system, forecasting methods—time series, casual and predictive forecasting methods, selection of a forecasting method.

Materials management. Purchasing, distribution and inventory control, inventory concepts, types of inventories. Inventory costs, economic order quantity, economic production quantity, lead time, safety stock. Basic concept of material requirements planning (MRP). Just in time (JIT).

Group B

Scheduling. Scheduling process, scheduling for a multistage production system, sequencing production operations, Johnson's rule.

Facilities management. Plant location—factors influencing plant location, cost factors, plant location decision process, selection of a location for new facilities, evaluation of alternative regions and sub-regions. Plant layout—objectives, decision process, types of layouts, comparison of layouts. Line balancing and sequence analysis concepts. Materials handling—devices for materials handling, basic considerations in the selection of materials handling system.

Human factor engineering: Methods analysis and works measurement, methods study, process analysis, operation process chart, operator process chart, motion study, principles of motion economy, motion analysis. Time study—types of studies, procedure for job time study, physical environment.

Quality management: Three aspects of quality, functional responsibility for quality in a manufacturing system, economics of quality assurance, quality control, QC decision variables, process control, control charts, acceptance sampling, single, double and sequential sampling plans, concept of total quality control (TQC).

Maintenance management: Maintenance functions, concept of reliability engineering, reliability improvement, preventive maintenance, preventive maintenance policy, repair policy, replacement decisions, queuing theory and its applications in maintenance.

Introduction to PERT/ CPM.

Recommended Books

- .. S N Chary. Theory and Problems in Production and Operations Management. Tata McGraw Hill Publishing Co. Ltd., New Delhi.
- .. E S Buffa and R K Sarin. Modern Production/ Operations Management. John Wiley International.

MATERIALS & METALLURGICAL ENGINEERING

The Booster of Civilisation

As one of the cradles of civilisation, Indian contribution to the field has been profound and pioneering. Examples abound from the metal-work and jewellery of the Indus Valley civilisation to the unaffected iron pillar at New Delhi (4th century A.D.) in substantial quantities. The Copper and Bronze Age followed by the Iron Age transformed the ancient civilisations across the world in the Indus-Valley, China, Egypt, Mesopotamia and Babylon. In other words, the civilisations were cast in metals.

The Engineering as the Backbone

The word metallurgy is said to have originated from Greek words and it means metal and working. Metallurgy as a branch of engineering is concerned with the extraction and production of metals and alloys, their adaptation to use, and their performance in service. As a science, metallurgy is concerned with the chemical reactions involved in the processes by which only metals are produced and extends to the chemical, physical and mechanical behaviour of metallic materials.

Material science on the other hand embraces a wider spectrum to include detailed aspects of both metals and non-metals. In material science the finer details of materials in terms of bondage between atomic particles are researched for and the extrinsic properties and gross behaviour in application are quantified in terms of their intrinsic properties. The marriage of metals and non-metals for specific applications has been possible for a penetrating understanding and knowledge of the behaviour of materials through the innovative steps in material science.

Branching of a Tree

The field of metallurgy may be divided into process metallurgy (production metallurgy, extractive metallurgy) and physical metallurgy. Metal processing is a part of process metallurgy

and the mechanical behaviour of metals, apart of physical metallurgy.

The emergence of material science and engineering is the result of developments that have occurred through the years. The most significant among these are—research in the materials-related basic sciences and the materials discipline, scientific and technological innovations, and organisational plus infrastructural developments in industry, educational institutions and the government R & D sectors.

Many disciplines and subdisciplines, in particular, metallurgy, ceramic technology, polymer and condensed matter sciences, and their engineering and industrial applications, exist as distinct identities within the broader concept of material science and engineering.

Many Faces of Materials

The lesson that energy can neither be created nor be destroyed applies also to the materials which man receives from Nature. Yet for the sake of gross utilization, the materials are categorised as naturally occurring or man-made, extracted or synthesized, inorganic or organic, structural or nonstructural, depending upon their origination or use. But a finer detailing is called for as the

associated science and technology differ widely due to the individual nature and application of the material. Thus, the materials are classified as metals and alloys, ceramics and glasses, polymers and elastomers, fibre and composite materials on the one hand based upon their nature and as industrial, electrical, electronics superconducting, nuclear, magnetic, optical, biomedical and the likes based upon their applications. Each face, at times overlapping, gives rise to dimensions in its own right.

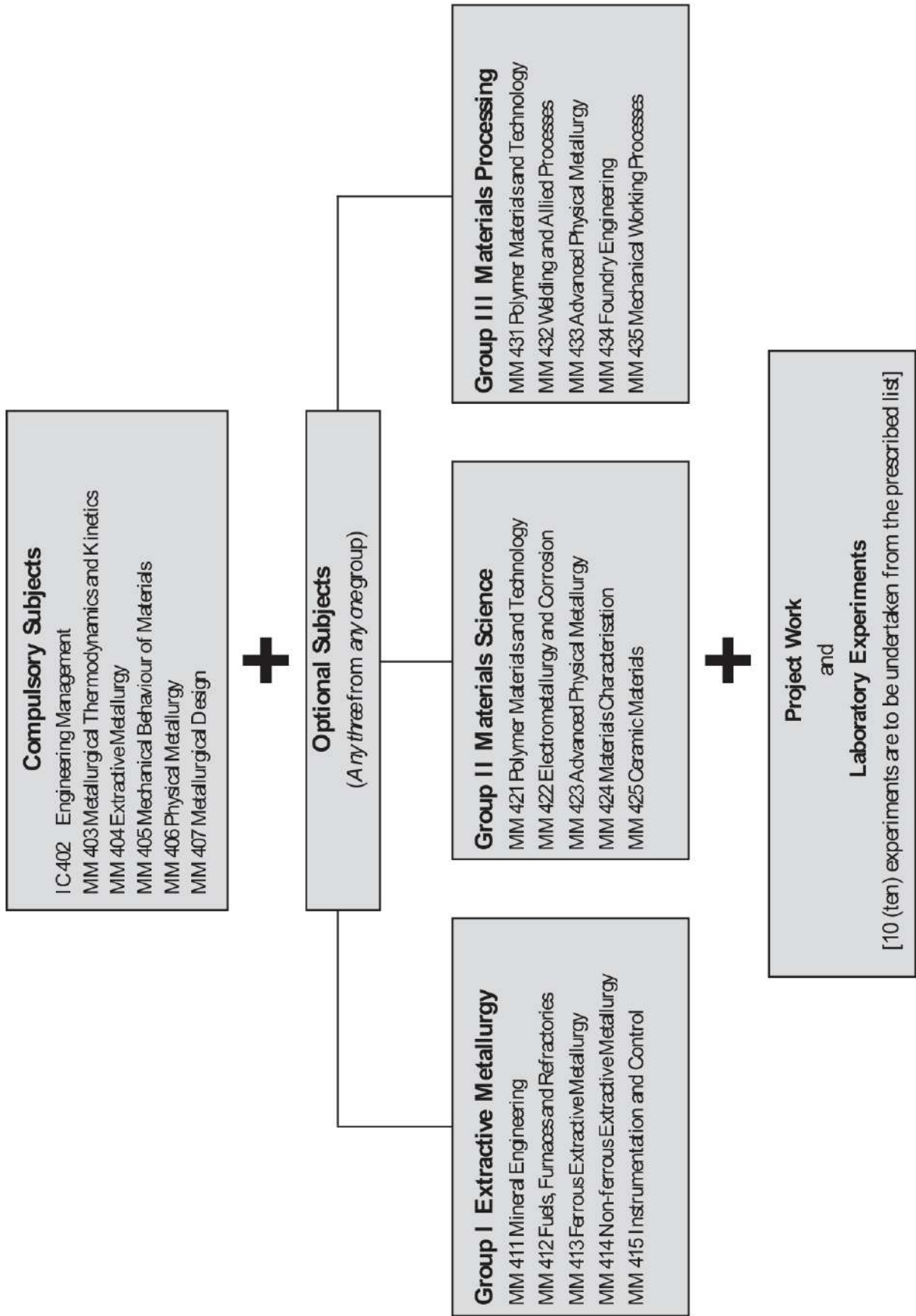
Indian Stride

Formal study of metallurgy in recent times started when the Banaras Hindu University established the College of Mining and Metallurgy in 1923. Such courses were also started early at the Bengal Engineering College, Shibpur, the Indian Institute of Science, Bangalore and the University of Roorkee. Realising the need for research and development for the sake of self-sufficiency and for exploiting Indian minerals which have unique characteristics, The National Metallurgical Laboratory was set up in 1950. Other institutions known for their work in allied field are at the Regional Research Laboratories at Bhubaneswar and Bhopal, the Central Glass and Ceramic Research Institute, Kolkata, etc.



Iron Pillar of Delhi

MATERIALS AND METALLURGICAL ENGINEERING



MATERIALS & METALLURGICAL ENGINEERING

IC 402

ENGINEERING MANAGEMENT

(See page 13, subject IC 402)

MC 432

METALLURGICAL THERMODYNAMICS AND KINETICS

Group A

State of a system. Extensive and intensive properties. First law of thermodynamics, capacity of gases and solids. Hess' law, enthalpy, Kirchhoff's laws.

Second law of thermodynamics. Entropy. Entropy changes in gases. Trouton's and Richard's combined statement of first and second laws of thermodynamics. Helmholtz and Gibbs free energies.

Concept of equilibrium. Thermodynamic potential conditions equilibrium. Maxwell's equations. Activity, activity coefficient and equilibrium constants for homogeneous and heterogeneous systems. Clausius-Clapeyron equation.

Third law of thermodynamics. Partial molar quantities. Gibbs-Duhem equation. Raoult's and Henry's laws. Standard states. Gibbs phase rule.

Group B

Electrolytic solutions, electrode potential, chemical and electrical energy, standard reference electrode, polarisation, over voltage, EMF and galvanic electrodeposition of metals and alloys.

Adsorption and absorption. Gibbs equation.

Arrhenius equation. Activation energy.

Homogeneous and heterogeneous reaction. Orders and molecularities of reactions. Activated state. Nucleation and growth. Diffusion.

Recommended Books

.. D R Gaskell. Introduction to Metallurgical Thermodynamics. McGraw-Hill International.

.. R H Tuptkary. Essentials of Metallurgical Thermodynamics. Khanna Books, New Delhi

IC 404

EXTRACTIVE METALLURGY

Group A

Formation of ores and minerals. Classification of ores and minerals. Definitions of various unit operations. Typical flow sheets for metal extraction processes.

Thermodynamics: Molten systems, slags and electrolytes. Kinetics: Gas-solid, liquid-solid, liquid-liquid and gas-liquid reactions.

Group B

Fuels and ores preparation: Fuels used in extraction—drying, calcination, roasting and agglomeration.

Reduction of metal oxides: Thermodynamics of oxide reduction with emphasis on ores of iron, lead and zinc. Blast furnace operations. Smelting and converting.

Refining process: Study with emphasis on steelmaking, vacuum degassing, distillation and zone refining.

Hydrometallurgy: Introduction to different unit processes like leaching, precipitation, ion exchange, solvent extraction, gaseous reduction and cementation.

Electrometallurgy: Current and energy efficiency. Examples from aqueous (Cu and Zn) and fused salt (Al) processes.

Recommended Books

.. A Ghosh and H S Ray. Principles of Extractive Metallurgy. New Age International (P) Ltd., New Delhi.

.. T Rosenquist. Principles of Extractive Metallurgy. McGraw-Hill International.

MM 405

MECHANICAL BEHAVIOUR OF MATERIALS

Group A

Elasticity. General state of stress and strain. Hooke's law, elastic constants and their relationships. Anisotropic elasticity. Elastic strain energy. Measurements of Young's modulus for metals, ceramics, polymers and composites. Non-elasticity.

Mechanism of elastic deformation. Atomic bonding and atomic packing in metals, polymers, ceramics and intermetallics. Energy distance curves for different materials. Effect of bonding and packing characteristics on elastic module of materials.

Plasticity. Yield criteria. Flow curve and work hardening. Constitutive relationships.

Mechanism of plastic deformation. Plastic deformation by slip, twinning, diffusional flows and grain boundary sliding. Crystallographic character of slip, critical resolved shear stress and theoretical shear strength of crystals.

Testing of metals. Tensile, compressive, hardness and impact of testing methods.

Group B

Elements of dislocation theory. Vacancies, interstitial and planar defects in crystals. Edge, screw and mixed dislocations and dislocation loops. Conservative and non-conservative

movements of dislocation. Stress required in move dislocation. Stress field and strain energy of dislocation. Line tension and forces on dislocation, forces between dislocations. Dislocation in FCC and BCC crystals and in ordered structures. Stacking fault energy and anti-phase boundary energy. Dislocation multiplication and pile-ups. Yield point phenomena and strain aging.

Strengthening mechanism. Strain hardening, deformation behaviour of polycrystals. Grain boundary, solid solution, precipitation, dispersion and fibre strengthening.

High temperature deformation and creep. Superplasticity. Primary, secondary and tertiary creeps, secondary creep rate deformation mechanism maps and plots. Creep resistance materials. Creep testing methods.

Fracture and fracture toughness of materials. Griffith's theory, critical energy parameter, critical stress intensity factor and fracture toughness.

Fatigue. Fatigue of uncracked and cracked components. Crack propagation rate in fatigue and its mechanism. Creep fatigue interactions. Fatigue testing methods.

Recommended Books

.. G E Dieter. Mechanical Metallurgy. McGraw-Hill International.

.. Brick, Gordon and Philips. Structure and Properties of Metals and Alloys. McGraw-Hill International.

MM 406

PHYSICAL METALLURGY

Group A

Fundamentals of physical metallurgy. Lattices, unit cells, indexing of direction planes. Weiss zone law. Close packing of equal spheres. Common metallic structure. Atomic size. Voids in close-packed structures. Packing of unequal sphere. Substitutional and interstitial solid solutions. Hume-Rothery's rules. Introduction to amorphous material, liquid crystals, quasi-crystals, fullerenes.

Diffusion in metals and alloys: Fick's laws and Kirkendall effect. Diffusion along dislocations and grain boundaries. Fundamental concepts of diffusional and martensite transformations.

Phase diagrams: Binary system. Isomorphous system, Lever rule, congruent minima and maxima, miscibility gap. Eutectic, peritectic, monotectic, syntectic and metatectic systems. Equilibrium and non-equilibrium solidification. Intermediate phases. Elements of ternary phase diagrams. Typical phase diagrams: Fe-C, Cu-Ni, Cu-Zn, Al-Cu, Al-Si and Pb-Sn.

Group B

Heat treatment of ferrous alloys: Heat treatment of plain carbon and alloy steels. Hardening, annealing, normalizing and

tempering of steels and their effect on properties. Hardness and hardenability. Quenching media.

Isothermal transformation diagrams, martempering, austempering and managing. Surface hardening—carburizing, nitriding, carbonitriding, flame and induction hardening.

Heat treatment of non-ferrous alloys: Annealing of cold worked metals and alloys. Heat treatment of common copper alloys. Precipitation and age hardening. Temper designations for aluminium alloys.

Pyrometry: Thermocouples, resistance, optical and radiation pyrometers and their applications.

Recommended Books

.. V Raghavan. Physical Metallurgy. Prentice-Hall of India (P) Ltd., New Delhi.

.. RE Smallman. Physical Metallurgy. Butterworths, London.

MM 407

METALLURGICAL DESIGN

Group A

Elements of design: Elementary design of machine components as applied to metallurgical equipment. Elements of cupola design. Design of recuperators and regenerators.

Heating furnaces: Design of fuel hearth, flues and passages. Design of arc roof, suspended roof and furnace binding. Estimation of heat losses, heat balance and fuel requirements.

Group B

Electric furnaces: Design of heating elements in electric resistance furnaces. Efficiency and performance of induction and arc furnaces.

Advanced metallurgical design: Design of metallurgical furnaces—open hearth, blast furnace and LD converter.

Recommended Books

.. M W Thring. Science of Flames and Furnaces. Chapman and Hall, London.

.. Paschakis and J Pearson. Industrial Electric Furnaces and Appliances. Wiley Interscience, New York.

.. T Rosenquist. Principles of Extractive Metallurgy. McGraw-Hill International.

.. W M Kayes and A L London. Compact Heat Exchangers. McGraw-Hill International.

MM 411

MINERAL ENGINEERING

Group A

Mineralogical investigations. Role of microscope, spectroscopy, microchemistry and other determinative methods.

Liberation and severance—methods of obtaining severance, determination of liberation.

Comminution. Broad classification. Primary breaking operations. Intermediate crushing by crushers, cone, roll and impact crushers. Ball and tumbling mills—fine grinding. Closed and open circuit grinding. Determination of power consumption.

Sizing. Screen analysis, sizing curves, industrial sizing, screening—revolving and vibrating screens. Screen efficiency and capacity. Classification: Laws, wet and dry methods. Types of classifiers—stationary, mechanical, centrifugal and hydraulic. Cyclones.

Gravity concentration. Jigging, bedding and shaking. Riffled tables, vanners and tilting tables. Heavy liquid and heavy media separations. Spiral concentrators and other slime recovery units.

Group B

Flotation. Physico-chemical principles. Chemistry of flotation reagents and their functions. Flotation processes. Froth flotation machines. Concentration of copper, lead and zinc ores by flotation. Flotation of non-sulphide ores of copper and lead, dolomite, fluorspar, gypsum, phosphates, manganese, silica, silimanite, graphite and coal.

Electrical and magnetic concentration. Electrostatic and magnetic separations, dry and wet type separators. Applications to mineral beneficiation.

Dewatering. Draining, thickening and sedimentation. Filtration by continuous vacuum and pressure filters. Centrifuges. Elements of drying—description and application of hearth and rotary dryers.

Other concentration methods. Handpicking, amalgamation and thermal processes.

Recommended Books

.. A M Gaudin. Principles of Mineral Dressing. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

.. A F Taggart. Elements of Ore Dressing. John Wiley and Sons, New York.

MM 412

FUELS, FURNACES AND REFRACTORIES

Group A

Fuels. Constitution, classifications and washing of coal. Composition of ash, comparative study of solid, liquid and gaseous fuels, selection criteria of coal for metallurgical purposes. High and low temperature carbonization and bi-products. Combustion theory and problems. Producer gas and water gas. Regeneration, recuperation and waste heat boilers. Fuel efficiency.

Furnaces. Combustion devices for solid, liquid and gaseous fuels. Various methods of firing and modes of combustion of

coal and coke in all cases. Natural, induced, forced and balanced draft. Theory and calculation of natural draft and capacity of chimney. Regulation of primary, secondary and excess air and furnace draft for efficient combustion.

Group B

Methods of firing of liquid and gaseous fuels. Principles of burner design for liquid and gaseous fuels. Pulverized fuel firing. Sources of heat losses in furnaces and methods to prevent insulation. Fuel economy and thermal efficiency of furnaces. Simple numerical examples. Different furnaces used in metallurgical industries and materials of construction. Elementary treatment of use of flow modes to study furnace characteristics.

Refractories. Refractory materials and their physical and chemical properties. Raw materials, manufacture, properties and uses of silica, fire-clay, basic composite and natural refractory materials. Refractory aspects of furnace construction with reference to important metallurgical industries like iron and steel, copper and aluminium.

Recommended Books

.. S Sarkar. Fuels and Combustion. Orient Longman Ltd., New Delhi.

.. Gupta. Elements of Fuels Technology. khannabooks.com

MM 413

FERROUS EXTRACTIVE METALLURGY

Group A

Ores and preparation. Indian iron ores and their composition. Location and evaluation. Beneficiation of ores and operations like calcination, concentration and agglomeration. Preparations and properties of fuels and fluxes.

Iron production. Blast furnace accessories, construction of blast furnace and layout. Blast furnace operation. Physical and chemical principles of furnace operation. Economy of hot and dry blasts. Furnace charge calculations. Control of slag, handling of products and utilisation of by-products like gas and slag.

Group B

Recent developments in blast furnace. Desulphurization, carbon lining, lime injection, high top pressure and steam injection. Instrumentation and control in blast furnace. Production of iron in low shaft and electric furnaces. Electric smelting and production of ferro-alloys.

Steelmaking. Various steelmaking processes. Use of oxygen in steelmaking. Selection of refractories for steel manufacturing. Casting pit practice methods of teeming, care and protection of ingot moulds. Defects in steel ingots, their causes and prevention. Continuous steel casting. Recent developments in steelmaking.

Recommended Books

- .. R H Tupkary. Modern Iron Making. Khanna Publishers, Delhi.
- .. R H Tupkary. Modern Steel Making. Khanna Publishers, Delhi.
- .. A K Biswas. Principles of Blast Furnace Iron Making. SBA Publications, Kolkata.

MM 414

NON-FERROUS EXTRACTIVE METALLURGY

Group A

Introduction. General flow-sheet for metal production from non-ferrous ores. Definitions and applications of various unit operations and unit processes involved in pyroprocessing.

Unit processes in pyrometallurgy. Reduction and smelting, including physical chemistry and Ellingham's diagrams. Converting, halide metallurgy—high temperature refining—distillation, vacuum degassing and zone refining.

Group B

Unit processes in hydrometallurgy. Leaching—mechanisms and kinetics, types and techniques of leaching. Solution purification—chemical precipitation on exchange, solvent extraction. Recovery of metal values—gaseous reduction of solutions, electrolysis, solvent extraction, cementation.

Electrometallurgy. Bourbaix diagram. Electrowinning. Electrorefining.

Recommended Books

- .. K P Abraham, H S Ray and R Sridhar. Extraction of Nonferrous Metals. Affiliated East-West Press (P) Ltd., New Delhi.
- .. J Newton. Extractive Metallurgy. John Wiley and Sons, New York.

MM 415

INSTRUMENTATION AND CONTROL

(See page 16, subject CH 415)

MM 421

POLYMER MATERIALS AND TECHNOLOGY

(See page 17, subject CH 431)

MM 422

ELECTROMETALLURGY AND CORROSION

Group A

Principles of electrochemistry. Laws of chemical and electrochemical equilibrium. Interpretation and measurement of current—voltage curves, emf of galvanic cells. Nerquist equation. Bourbaix diagram. Electrode potentials, decomposition potential, polarization, overvoltage and practical utilities. Passivation phenomena.

Electroplating, electrotyping and anodizing. General principles of codeposition and plating from aqueous and non-aqueous baths, methods of plating of Cr, Cd, Zn, Sn, Cu, Ag, Ni and bright Ni, codeposition with reference to plating of brass and alloys of tungsten. Electrotyping of metals.

Anodizing and plating Al, methods of testing of electrode deposit with reference to porosity, thickness and microhardening.

Group B

Electrorefining of metals. General principles and practice of electrowinning of Cu, Ag, Pb, Ni, Fe, Zn and Sn from aqueous solutions and Al, Be, Ce, Mg and Na from fused salts.

Electroanalysis. Electrogravimetric analysis. Principles of potentiometric, conductometric and trace analysis by polarography and amperometry. Electrophoresis as a method of separation of isotopes.

Forms of corrosion. Uniform, localised and galvanic corrosion, oxygen and hot corrosion, hydrogen embrittlement. Corrosion control by design, environmental change, and coating.

Cathodic and anodic protection. Corrosion properties of materials. Analysis of corrosion failure. Engineering trends in corrosion studies.

Recommended Books

- .. S Narayan and R Saran. An Introduction to Electrometallurgy. Standard Publishers and Distributors, Delhi.
- .. W A Koehler. Principles and Applications of Electrometallurgy. John Wiley and Sons, New York.
- .. Raj Narayan. An Introduction to Metallic Corrosion and Its Prevention. Oxford and IBH Publishing Co. (P) Ltd., New Delhi.

MM 423

ADVANCED PHYSICAL METALLURGY

Group A

Solidification of pure metals—phenomena of under cooling. Solidification of alloys—cooling curves. Introduction to thermodynamics of phase transformations. Kinetics and mechanism of phase changes in solid state.

Metastable equilibrium-iron-carbon diagram. Transformations in steel under non-equilibrium conditions. Eutectoid and martensitic transformations to austenite—both in isothermal manner and during continuous cooling. Heat treatment of steel. Hardenability. Quenching and transformation stresses. Surface hardening processes. Thermo-mechanical treatment of steel.

Group B

Physical metallurgy of cast iron and its heat treatment. Important solid state transformations during equilibrium and non-equilibrium conditions in non-ferrous systems. Precipitation phenomena in solid solutions. Age hardening—its theories. Quench and strain aging. Phenomena of temper brittleness.

Preparation of metallographic examination. Mechanical polishing, electrolytic polishing. Macroexaminations, interpretation of micro structures. Methods of detection of phase changes. Construction of equilibrium diagrams by various methods and ternary diagrams for Fe-alloys with reference to altering of microstructure and mechanical properties. Isothermal transformation in steel. Order-disorder reaction.

Recommended Books

- .. RE Smallman. Physical Metallurgy. Butterworths, London.
- .. RW Cahn (Ed). Physical Metallurgy. John Wiley and Sons, New York.

MM 424 MATERIAL CHARACTERISATION

Group A

Stereographic projection. Generation of X-rays, continuous and characteristics spectrum. Absorption of X-rays. Bragg's law, diffraction methods, diffraction under non-ideal conditions. Intensity of diffracted beam, powder method, indexing of cubic and non-cubic crystals.

Precise lattice parameter determination, solus curve determination, chemical analysis, preferred orientation and texture determination of particles, sizes, etc.

Group B

Electron microscopy—principles, thin film and replication techniques, nature of contrast from dislocations, stacking faults and second phase particles.

Other methods of detecting phase changes, thermal analysis, differential thermal analysis and magnetic methods.

Recommended Books

- .. G Thomas. Transmission Electron Microscopy of Metals. John Wiley and Sons, New York.
- .. A Taylor. An Introduction to X-ray Metallography. John Wiley and Sons, New York.

MM 425 CERAMIC MATERIALS

Group A

Characteristics of ceramic solids. Introduction to ceramics, common ceramic crystal structures, silicates, clay minerals, graphite and carbides.

Structural imperfections, solid solutions, Frenkel and Schottky defects, dislocations, non-stoichiometric solids, diffusion in crystalline and non-stoichiometric solids.

Group B

Development of microstructure in ceramics. Ceramic phase equilibrium diagrams. Nucleation, grain growth, sintering and vitrification, microstructure of ceramics.

Properties of ceramics. Elastic behaviour, toughness, strength, creep, and plastic deformation, thermal properties, optical properties, electrical conductivity, dielectric and magnetic properties.

Recommended Book

- .. WD Kingery, H K Bowen and D R Uhlmann. Introduction to Ceramics. Wiley Interscience, New York.

MM 431 POLYMER MATERIALS AND TECHNOLOGY

(See page 17, subject CH 431)

MM 432 WELDING AND ALLIED PROCESSES

Group A

Classification of welding processes; Basic fusion operations; Gas and arc welding; Welding equipment and materials.

Various arc welding techniques (TIG, MIG, submerged arc, etc); Resistance welding; Special welding processes (thermit, laser, electron beam, explosive, etc); other solid state welding processes; Welding of special metal alloys.

Group B

Heat flow in welding: Pre-heat and post-heat treatment; Residual stresses; Weldability; Strength of weld joints; Inspection and testing of weld joints.

Principles of brazing and soldering; Wetting phenomenon; Capillary flow, pre-cleaning and use of fluxes; Application to important ferrous and non-ferrous alloys. Design considerations in welding.

Recommended Books

- .. RS Parmar. Welding Processes and Technology. Khanna Publishers (P) Ltd., Delhi.

- .. R L Little. Welding and Welding Technology. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. P N Rao. Manufacturing Technology. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. A C Davies. Welding. Cambridge University Press, USA.

MM 433

ADVANCED PHYSICAL METALLURGY

(See page 75, subject MM 423)

MM 434

FOUNDRY ENGINEERING

Group A

Casting processes. Classifications, applications, advantages and limitations.

Pattern making. Requirements, pattern materials, machines and tools for pattern-making, allowances, types of patterns, design of patterns.

Moulding. Moulding sands—properties, preparation and testing; Moulding processes; Machine moulding; Core and core making.

Gating system. Elements of gating system; Design of gating system—sprue, choke and gates.

Melting and pouring. Melting equipment for foundries. Metallurgical characteristics of cast metals, pouring time and temperature.

Group B

Solidification. Principles of solidification; Estimation of solidification time.

Risling. Design of risers and their placements.

Quality considerations. Casting defects; Inspection and testing of casting; Design of castings.

Special casting processes. Investment and shell casting; Permanent mould casting; Die casting; Centrifugal casting; Continuous casting.

Recommended Books

- .. B W Taylor, M C Fleming and J Wulff. Foundry Engineering. New Age International (P) Ltd., New Delhi.
- .. P L Jain. Principles of Foundry Technology. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

- .. R W Hein, C R Laper and Rosenthal. Principles of Metal Casting. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. P N Rao. Manufacturing Technology. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

MM 435

MECHANICAL WORKING PROCESSES

Group A

Elastic and plastic deformation of single crystal and polycrystalline aggregates. Slipping, twinning, work hardening, flow and fracture, annealing, recovery, recrystallisation and grain growth.

Hot and cold working, orange peel effect, stretcher, strength, strain, yield point phenomena. Aging—strain and quench aging; strain age hardening.

Group B

Elementary analysis and metallurgical principles involved in various working operations like rolling, forging, wire drawing, deep drawing, stamping and extrusion, and their applications.

Polymer materials, mechanical behaviour of polymer materials, forming and shaping of polymer materials (blow, vacuum, compression, transfer and injection moulding, extrusion, etc.)

Process description, production of metal and ceramic powder. Reduction, atomisation, mechanical comminution and electrolysis process.

Blending of powder. Briquetting, sintering, sizing, coining, machining, impregnation, infiltration, plating. Heat treatment.

Properties of metal powders and finished parts. Application of powder—metallurgy techniques in the field of porous bearing, machine parts, friction material, tungsten filaments.

Design considerations in powder metallurgy.

Recommended Books

- .. G E Dieter. Mechanical Metallurgy. McGraw-Hill International.
- .. A V K Suryanarayana. Testing of Metallic Materials. Prentice-Hall of India (P) Ltd., New Delhi.
- .. J R Fried. Polymer Science and Technology. Prentice-Hall of India (P) Ltd., New Delhi.
- .. G S Upadhyay. Powder Metallurgy Technology. Cambridge University Press, USA.

The Venerable Tradition

India has had a venerable tradition in mining, dating back to pre-Harappan times. Carbon-dating of artefacts from Rajpura-Daribam in Rajasthan attests to the fact that the mine worked as far back as 1000 BC. Even during the Indus Valley Civilisation which flourished more than 5000 years ago, gold jewellery, copper vessels and other artefacts were in use. The widely scattered slag heaps of iron, steel, zinc, lead, copper and gold in certain parts of Bihar, Karnataka and Rajasthan go to suggest the evidence of mining in India in ancient times. While Kautilya (400-300 BC) in his *Arthashastra* has made incidental reference to mining, Amarsimha in his *Amarkosha* suggested the classification of metals and minerals. The Indian diamond industry, noted for the Kohinoor, enjoyed world wide monopoly at one time. India has enjoyed a respectable antiquity, a rich heritage and hence a prestigious position in the annals of mining over several centuries.

Modern Mining – Indian Perspective

Regular mining of coal was started in Raniganj in 1814 and copper mining in the Singhbhum copper belt in Bihar in 1857. Mica deposits were opened up in Bihar in 1857, in Andhra Pradesh in 1887 and in Rajasthan later. Manganese ore deposits were discovered in Central India in 1829 and in Southern India in 1891. The Kolar gold mines were started in 1871. The Digboi oil fields in Assam came up in 1888. Many other mines, quarries and oil fields have since been explored.

The Indian mining industry constitutes a large disparate conglomerate, with around 400 coal mines, 720 mines for metallic minerals, and over 2600 mines for non-metallic minerals. In mineral resources, India has a large excess in iron ore, titanium, thorium, rare earths and mica, a surplus deposit of bauxite, corundum, beryl, magnesite, manganese and zirconium, a self-sufficiency in arsenic, barium, chromium, coal, uranium and

The Speculative Engineering

Once an art of speculation by only a few handful experts, Mining Engineering is now concerned with scientific exploration of the rich resources of materials hidden under the crust of the earth, exploitation of technology for safe and economic extraction of the same, which nature has transformed and stored, and efficient management for the execution of all actions related to mining of minerals in any form – solid, liquid and gas. Geological understanding of the formation of earth crust and trapped minerals, mapping of deposits and their distribution density through interpretation from space-age technology, designing adaptable mining machinery, forecasting and prevention of mining hazards, implementation of safe and rescue measures – all such aspects come under the purview of mining engineering discipline.

vanadium, and an unfortunate deficiency in bismuth, lead, mercury, nickel, cobalt, copper and the noble metals.

The Pioneer Organisations

Except for sophisticated machinery for advanced mechanization, indigenously designed and manufactured mining machinery are now available in India.

Auxiliary equipment such as electrical, ventilation, dewatering, dust suppression and methane monitoring systems are also indigenously available. Mining and Allied Machinery Corporation (MAMC), Durgapur; Heavy Engineering Corporation (HEC), Ranchi; Tata Engineering and Locomotive Co. Ltd (TELCO), Jamshedpur, Hindustan Motors Ltd, Chennai; and Larsen and Toubro Ltd, Mumbai are some of the leading manufacturers of mining equipment. The country has developed indigenous capacity even in the field of off-shore exploration and exploitation through such organisations as Engineers India Ltd, Mazagaon Docks Ltd, Mumbai, and the Oil & Natural Gas Corporation (ONGC).

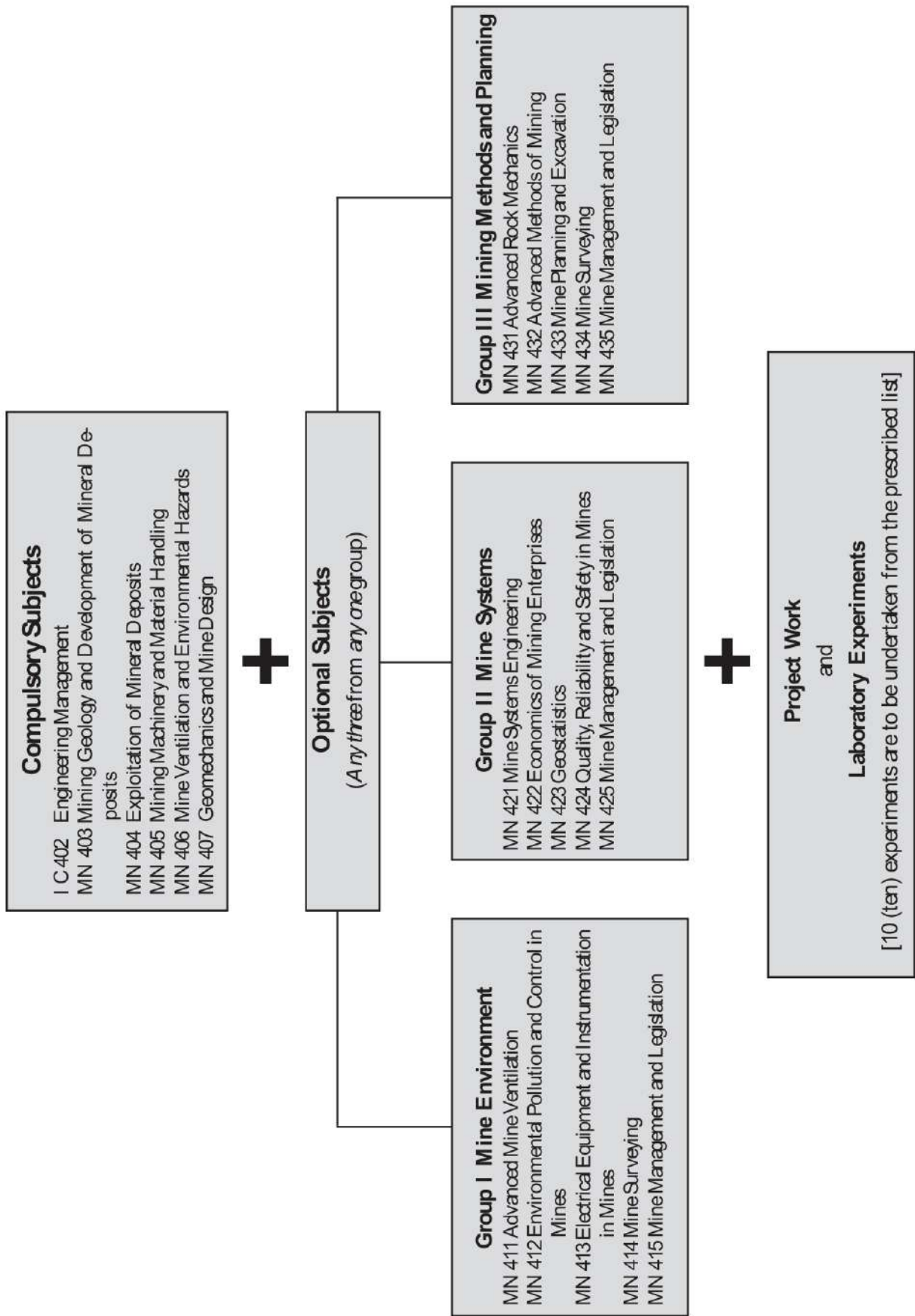
In order to interlink the exploration of minerals in line with the national policy, the Mines and Minerals (Regulation and Development) Act, 1948, had been enacted by the Government of India. The Indian Bureau of Mines, Nagpur was created in the same year to coordinate the development activities.

The Indian School of Mines, Dhanbad (1926), Deemed as a University, imparts education in mining engineering, petroleum engineering and geology at graduate and postgraduate levels. Several research organisations like CMR have also been established.



Process Control System for a Colliery

MINING ENGINEERING



MINING ENGINEERING

IC 402

ENGINEERING MANAGEMENT

(See page 13, subject IC 402)

MN 403

MINING GEOLOGY AND DEVELOPMENT OF MINERAL DEPOSITS

Group A

Physical geology, petrology—sedimentary, igneous and metamorphic rocks. Basic principles of stratigraphy. Structural geology—faults, folds, joints, etc. Process of mineral formation. Classification of mineral deposits.

Mode of occurrence, distribution and origin of important metallic and non-metallic minerals including fuel minerals.

Prospecting and exploration of mineral deposits—geological, geophysical and geochemical methods, groundwater. Geological documentation for mine planning.

Group B

Introduction of mining technology, classification and properties of explosives and blasting accessories. Mechanics of rock breaking—drilling and blasting. Blasting practices. Blast vibration monitoring.

Mine entries—types, location, orientation, etc. Primary and secondary development underground. Shaft sinking—conventional and special methods. Deepening and widening of shafts, tunneling.

Recommended Books

- .. R N P Arogyaswamy. Courses in Mining Geology. Oxford & IBH Publishing Co. (P) Ltd., New Delhi.
- .. P K Mukherjee. A Text Book of Geology. World Press, Kolkata.
- .. L J Thomas Mathuen. An Introduction to Mining. Australia.
- .. D J Deshmukh. Elements of Mining Technology. Vidyasawa Prakashan, Nagpur.

MN 404

EXPLOITATION OF MINERAL DEPOSITS

Group A

Methods of working coal by pillar mining methods—applications, layouts, development and extraction by partially and fully mechanised methods, Longwall mining methods. Influence of depth, seam thickness, inclination, etc. Continuous mining.

New developments and special methods of mining thick seams, support of roadways and face supports. Power support. Hydraulic stowing. Subsidence and strata control.

Group B

Methods of development and stoping metalliferrous deposits—open stopes, filled stopes, shrinkage stopes and caving methods. Handling of ore and waste materials. Stope mechanisation.

Opencast methods of mining—opening a pit layout. Development and design of benches, drilling, blasting, loading and transport. Continuous mining systems. Placer mining techniques.

Recommended Books

- .. R D Singh. Principles and Practices of Modern Coal Mining. New Age International (P) Ltd., New Delhi.
- .. D J Deshmukh. Elements of Mining Technology. Vidyasawa Prakashan, Nagpur.
- .. E Pfeider. Surface Mining. SME/ AMIE Publications, USA.
- .. SK Das. Modern Coal Mining Methods. Lovely Prakashan, Dhanbad.

MN 405

MINING MACHINERY AND MATERIAL HANDLING

Group A

Principles and basic design features of mechanical, hydraulic and pneumatic power transmission. Transport machinery—rope haulage, locomotive, conveyors, their basic construction, operation and safety devices.

Hoisting system—system components, duty cycle, torque time and power time diagrams. Drum and friction winders. Mining pumps—basic construction and operation. Pumping system in underground.

Group B

Electric, pneumatic and hydraulic drills. Cutting, loading and winning machinery for underground mines. Longwall and open cast mining machinery. Aerial ropeways—classification, construction and operations.

Principles of hydraulic and pneumatic conveying. Storage and reclamation of bulk materials. Developments in bulk materials handling technology.

Recommended Books

- .. D J Deshmukh. Elements of Mining Technology. Vidyasawa Prakashan, Nagpur.
- .. M A Ramlu. Mine Hoisting. Oxford & IBH Publishing Co. (P) Ltd., New Delhi.
- .. R D Singh. Principles and Practices of Modern Coal Mining. New Age International (P) Ltd., New Delhi.

MINE VENTILATION AND ENVIRONMENTAL HAZARDS

Group A

Heat and humidity in mines. Climate control and airconditioning. Mine illumination, noise and its control. Mechanics of airflow in mines, distribution of airflow. Natural and mechanical ventilation.

Fan—theory, characteristics, laws and selection of fan installation, series and parallel configuration. Auxiliary and booster ventilation. Ventilation survey and instruments. Ventilation planning and layouts, network analysis.

Group B

Mine gases—properties, detection, physiological effects, monitoring. Methane layering and methane drainage. Mine dust—physiological effects, monitoring and control.

Spontaneous heating and mine fires. Firedamp and coal dust explosions. Mine inundation, Rescue and recovery. Occupational health.

Recommended Books

- .. V S Vutukuri and R D Lama. Environmental Engineering and Mine Ventilation. Cambridge University Press.
- .. M A Ramlu. Mine Disasters and Mine Rescue. Oxford & IBH Publishing Co. (P) Ltd., New Delhi.

GEOMECHANICS AND MINE DESIGN

Group A

Physico-mechanical properties of rocks and soils. Deformation characteristics and time dependent behaviour of rocks. Rock mass classification.

Stress analysis and theories of rock failure. Stress distribution around mine openings. In-situ stress and deformation measure.

Group B

Design of pillars, support design for mine roadways. Mechanics of caving and support design for longwall workings.

Rock slope design and design of pit layout, introduction to finite element methods.

Recommended Books

- .. A R Jumikis. Rock Mechanics. Trans Tech Publication.
- .. S S Perg and H S Chiang. Longwall Mining. Wiley International, New York.

ADVANCED MINE VENTILATION

Group A

Climate control: Psychrometry, mixing of air flows, hygrometric surveys. Heat stress indices. Heat load sources in mines—estimation. Geothermal heat transfer. Design of air cooling systems: refrigeration, cooling towers, spray chambers, and cooling coils for heat exchange.

Dynamics of air flow: Turbulent flow distribution through rough pipes. Frictional losses. Shock losses—estimation for bends, area changes, splits and junctions. Drag losses. Plotting of pressure gradients for pipe flow.

Group B

Ventilation networks: Series and parallel systems. Concept of boosters and regulators for flow control. Theory of network analysis: incidence, fundamental, and cut-set matrices. Hardy-Cross iterative procedure. Controlled flow networks—linear programming and CPM applications. Recent developments in mine ventilation.

Natural ventilation pressure. Fan and system interaction, fans in series and parallel. Dust control in underground workings. Controlled recirculation.

Recommended Books

- .. G B Misra. Mine Environment and Ventilation. Oxford University Press, Kolkata.
- .. H L Hartman, et al. Mine Ventilation and Air-conditioning. Wiley Interscience, New York.
- .. J Burrows, et al. Environmental Engineering in South African Mines. Mine Ventilation Society of South Africa.

ENVIRONMENTAL POLLUTION AND CONTROL IN MINES

Group A

Atmospheric considerations: Basics of meteorology, atmosphere, ozone layer, and green house effect. Contaminant dispersion, plumes from chimney, Gaussian plume dispersion, and isokinetic sampling. Point, line, and area sources of contamination. Significant air pollution parameters, CPCB and NEERI norms, effects, assessment, and sources. Dust control in mines, mills, and haul roads.

Aquatic system: Water cycle. Water quality parameters, standards, measurement, and instrumentation. Heavy metal pollution, acid mine drainage, and sediment loading from mine effluents—problems and control options. Tailing dams—construction aspects and environmental management. Basics of ground water flow and contaminant dispersion.

Group B

Aspects of land: Soil properties in relation to plant growth. Top soil. Soil conservation. Reclamation and revegetation: design of overburden and waste dumps, and embankments. Erosion control and slope stability. Soil amendment schemes. Plant species—suitability and selection. Alternative land uses. Use of flyash in minereclamation.

Miscellaneous factors Noise control and ground vibrations. Issues in the preparation of EMP/ EIA. Legislation relating to environmental protection. ISO 14000. Visual impact due to mining. Environmental economics and auditing.

Recommended Books

- .. O P Gupta. Elements of Environmental Pollution Control. Khanna Books (P) Ltd., New Delhi.
- .. C S Rao. Environmental Pollution Control Engineering. New Age International (P) Ltd., New Delhi.
- .. C G Down and J Stocks. Environmental Impact of Mining. Applied Science Publishers Ltd., London.

MN 413

ELECTRICAL EQUIPMENT AND INSTRUMENTATION IN MINES

Group A

Mine power supply: Choice of voltage in surface and underground supply; tariff computation; Mine cables—construction, installation, fault location; Gate end boxes and switchgears; Earthing methods; Protective devices; Overload, undervoltage, earth leakage, DC supply—rectifiers, storage batteries.

Electrical equipment: Mining transformers, lighting transformers; AC and DC motors—speed torque characteristics, starting, braking speed control; Drives for haulage, ventilation fans, pumps, compressors, electric locomotives, winders; Introduction to thyristor devices; Flame-proof and intrinsic safety.

Group B

Control and instrumentation: Open- and closed-loop systems, remote control, sequence control, winder control, control of open cast mine equipment; Sensors for measurement of various operational, environmental and safety parameters in underground and open cast mines.

Communication and data transmission: Mine telephone systems; Signalling systems, local area network (LAN)—FOLAN.

Recommended Books

- .. D V S Murty. Transducers and Instrumentation. Prentice-Hall of India (P) Ltd., New Delhi.
- .. A Ambikapathy. Automatic Control Systems. Khanna Book Publishing (P) Ltd., New Delhi.
- .. P S Bimbhra. Electrical Machines. khannabooks.com

Khanna Book Publishing Co. Ltd., New Delhi.

- .. P K Chakrabarti. Electricity in Underground Coal Mining. CMPDIL, Gondwana Place, Ranchi.
- .. Nenad Marmovic. Electrotechnology in Mining. Elsevier Science Publishers, Amsterdam.

MN 414

MINE SURVEYING

Group A

Chain surveying, Compass-miner's dial. Contouring—characteristics, methods, uses. Leveling instruments—dumpy, tilting, and automatic levels. Leveling procedures, booking. Plane table surveying—methods and uses. Theodolite—different parts, horizontal and vertical angle measurements. Temporary and permanent adjustments.

Traversing—co-ordinate systems, problems, calculation of areas and volumes plotting, triangulation, trilateration. Tacheometry. EDM—principles of EDM and its applications. Gyrotheodolite—description and applications. Theory of errors. Total station.

Group B

Correlation through underground and surface surveys. Measurements of depth of shaft. Curves—elements of curves, types, methods of setting out. Slope surveying—tape triangulation, instrumental survey, transfer of slope plan to mine plan, string traverse. Subsidence surveying. Shaft surveying, borehole surveying.

Open pit surveying. Principles of photogrammetry. Field astronomy. Mine plans and projections. Statutory requirements. GPS and introduction to remote sensing.

Recommended Books

- .. David Clark. Plane and Geodetic Surveying. Constable & Co., London.
- .. T P Kanetkar and SV Kulkarni. Surveying and Levelling. Pune Vidyarthi Griha Prakashan, Pune.
- .. A Banister and S Raymond. Surveying. ELBS, Longman Ltd., UK.
- .. E A Winniberg. Metalliferous Mine Surveying. Mining Publications Ltd., London.
- .. JG Olliver and J Clendinning. Principles of Surveying. Van Nostrand Reinhold Co., UK.

MN 415

MINE MANAGEMENT AND LEGISLATION

Group A

Concept of management, concept of system, production system. Organisation structures, span of control, number of

levels and management functions. Production economics—kinds of costs, evaluation of capital investment and capital budgeting. Break even analysis.

Human factor engineering—methods, analysis and work measurement, method study. Time study—types of studies and procedures.

Materials management—purchasing, distribution and inventory control. Inventory concepts, types of inventories and their relative costs.

Group B

Development of mining legislation. Principal provision of Mines Act, Mines Rules.

Coal and metalliferous mine regulations and their interpretation.

Indian Electricity Rules, Mines Rescue Rules, and other related rules. Mine accidents—reports and records. Accident investigation and analysis. Disaster management.

Recommended Books

- .. H Koontz and H Wehrick. Essentials of Management. McGraw-Hill International.
- .. D D Seth. Encyclopedia of Mining Laws. Law Publishers (I) Pvt. Ltd., Allahabad.
- .. SK Das. Mine Management, Legislation and General Safety. Lovely Prakashan, Dhanbad.
- .. E S Buffa and R K Sarin. Modern Production/ Operation Management. John Wiley International.

MN 421

MINE SYSTEMS ENGINEERING

Group A

Introduction to systems engineering. System concept and analysis. Tools and methodologies of Operations Research. PERT/ CPM, resource allocation, crashing of network, monitoring and control of projects through network.

Introduction to linear programming: Graphical and simplex method, duality, sensitivity analysis. Transportation and assignment models. Integer programming.

Group B

Introduction to queueing theory. Basic structure of queueing models. Single channel—single server and other queueing models. Inventory system and models. EOQ and different inventory control systems. ABC analysis. Replacement of capital equipment.

Introduction to simulation, scope and limitation. Simulation of different mining subsystems and total system. Monte Carlo simulation for discrete systems. Some mining—oriented illustrations.

Recommended Books

- .. H A Taha. Operations Research: An Introduction. Prentice-Hall of India (P) Ltd., New Delhi.
- .. Narsingh Deo. System Simulation with Digital Computer. Prentice-Hall of India (P) Ltd., New Delhi.
- .. JD Wist and F K Levy. A Management Guide to PERT/ CPM. Prentice-Hall of India (P) Ltd., New Delhi.
- .. JK Sharma. Operations Research: Theory and Applications. Macmillan India Ltd., New Delhi.

MN 422

ECONOMICS OF MINING ENTERPRISES

Group A

Principles of micro and macro economics and the application of econometric techniques in mining industry. Mineral statistics—national and global. Important mineral deposits and minefields in India.

Theory and importance of sampling, different methods of sampling, classification and estimation of reserves. Computation for tonnage average assay width, stoping width, clear width, milling width, etc. Geostatistical techniques of computation of reserves and quality.

Group B

Financial appraisal methods, NPV, IRR, etc. Risk analysis for mining projects. Valuation of mines and mineral properties.

Methods of financing industrial enterprises. Constitution and organisation of enterprises. Mine productivity, costing, cost accounting and budgetary control in mines. Taxation, profit and loss accounts, balance—sheet.

Recommended Books

- .. K K Chatterjee. An Introduction to Mineral Economics. New Age International (P) Ltd., New Delhi.
- .. P Chandra. Fundamentals of Financial Management. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. RK Sinha and N L Sharma. Mineral Economics. Oxford and IBH Publishing Co. (P) Ltd., New Delhi.

MN 423

GEOSTATISTICS

Group A

Introduction to mineral exploration, estimation of ore reserves, different methods of reserve estimation—geometrical, distance weighting and geostatistical methods, review of geostatistical concepts—spatial statistics and their application in reserve estimation.

Review of basic statistics in mineral appraisal, classical statistics—normal and lognormal distributions and their

applications in reserve estimation, grade-tonnage curve; Correlation and regression, auto-covariance and autocorrelation; Theory and methods of sampling—drill hole compositing.

Group B

Theory of regionalized variables, variogram, semivariogram—sill, range, nugget effect, properties of variogram—isotropy, anisotropy, variogram models—linear, spherical, exponential, gaussian.

Kriging: Point kriging—kriging system of equations, kriging estimation variance, block kriging, applications of kriging in reserve estimation.

Recommended Books

- .. Elements of Mineral Exploration. Indian Bureau of Mines, Nagpur.
- .. JM Rendu. An Introduction to Geostatistical Methods of Mineral Evaluation. South African Institute of Mining and Metallurgy.
- .. E H Isaaks and R M Srivastava. Applied Geostatistics. Oxford University Press, New Delhi.

MN 424

QUALITY, RELIABILITY AND SAFETY IN MINES

Group A

The quality aspects, functional responsibility for quality in a manufacturing system, economics of quality assurance, quality control. QC decision variables. Process control. Control charts. Acceptance sampling, single, double and sequential sampling plans, concept of Total Quality Management (TQM).

Introduction to reliability concepts, basic statistics, probability distributions in reliability evaluation—exponential, normal, lognormal, and Weibull—failure rate, reliability function, application of reliability in mining system.

Network modelling concepts in reliability engineering—series system, parallel system, series-parallel system, partially redundant systems, network modelling of mining systems, reliability evaluation of mining equipment.

Group B

Safety in Indian mining industry, accident database, accident analysis—cause of accident, nature of injury, severity of injury, measures of accident rates—frequency rate, severity rate, regulatory measures of accident prevention, proactive measures of accident prevention.

Basic concept of risk. Risk analysis and mine accidents, hazard tree, fault tree and event tree analysis, systems approach in mine safety, development of safety engineering approaches,

human behaviour in mine accidents.

Recommended Books

- .. R Billinton and R Allan. Reliability Evaluation of Engineering Systems. Pitman Books Ltd., London.
- .. D B Brown. Systems Analysis and Design of Safety. Prentice-Hall of India (P) Ltd., New Delhi.
- .. D S Gloss and M G Wardle. Introduction to Safety Engineering. John Wiley and Sons, New York.
- .. S C Sharma & M P Poonia. Total Quality Management. khannabooks.com

MN 425

MINE MANAGEMENT AND LEGISLATION

(See page 82, subject MN 415)

MN 431

ADVANCED ROCK MECHANICS

Group A

Rock strata characterization: Geological structures in rock mass, characteristics of rock mass, joints in rock mass, joint survey techniques, rock mass classification systems. Methods of determination of strength and deformability of rock and rock mass, failure criteria for rock and rock mass.

Strata mechanics and ground movement—design of underground excavation in competent and incompetent rock, ground movement and control, rock burst theories of subsidence, subsidence prediction and control. Ground control and stabilization.

Group B

Theories of elasticity—propagation of elastic waves in rock medium and dynamic behaviour of rocks. Factors influencing stress concentration, zone of influence of an excavation, effect of planes of weaknesses and shape of excavation, delinearisation of zone of failure. Instrumentation—monitoring instruments, their operation and installation.

Finite element method and boundary element method, their application for stability analysis of excavation and slopes.

Recommended Books

- .. A R Jumikis. Rock Mechanics. Trans Tech Publications
- .. R H Brady and E T Brown. Rock Mechanics for Underground Mining. Allen Kuwin, London.
- .. CS Krishnamurthy. Finite Element Analysis. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

ADVANCED METHODS OF MINING

Group A

Recent trend of mechanisation in bord and pillar mining, longwall mining. Mining of thick seams—methods and design consideration for exploitation of thick seam by inclined slicing and integrated caving, special methods of mining with reference to Indian conditions, salvage operations in longwall mining; hydraulic mining.

Advanced metal mining—blast hole stoping, raise stoping, pillar recovery. Dilution, loss and recovery in stoping, stope design and production planning. Design and construction of special underground excavations. Mining in rock burst prone areas. Novel and innovating mining methods—leaching methods.

Group B

Orebody modeling. Pit geometry, determination of ultimate pit configuration—different methods. Production planning and calendar plan for mining programme. Equipment selection, design of haul roads.

Inpit crushing and conveying systems. Bucket wheel excavator—general applicability and fundamentals of operation. Crosspit conveying and high angle conveying.

Dump formation, types of waste dumps—internal and external. Dump formation method and corresponding equipment. Dump stability, stabilization methods and monitoring.

Recommended Books

- .. P Pfeider Eugene. Surface Mining. SME AMIE Publication, USA.
- .. G B Misra. Surface Mining. Oxford & IBH Publishing Co. (P) Ltd., New Delhi.
- .. RD Singh. Principles and Practices of Modern Coal Mining. New Age International (P) Ltd., New Delhi.
- .. H L Hartman. Introductory Mining Engineering. John Wiley and Sons, New York.

ADVANCED METHODS OF MINING

Group A

Principles of mine planning, short range and long range

planning and their integration. Strategic planning. Preliminary evaluation of mineral deposits. Stages of planning, feasibility study, detailed project report, their preparation. Mine planning, scheduling, monitoring and control. Application of network analysis. Economic productivity indices and estimation of cost and profit.

Theoretical consideration for opening up and development of mine field. Division of mine field and areas. Determination of optimal output, life and size of mine. Design of unit operations. Equipment selection, planning and control.

Group B

Pit top and pit bottom layout. Planning of power, workshop and surface bulk material handling systems. Planning of layout of waste and overburden dumps. Mine amalgamation, restructuring, reconstruction planning. Post mining land use planning and mine closure planning.

Mechanism of rock breakage and fracture. Rock fragmentation by explosive action, cutting, ripping and impacts. Principles of excavating machines—road headers TBM's, bucket excavators, etc. Excavated material handling systems. Flow of materials in bins and design of chutes. Mechanical and hydraulic transportation of ores and materials.

Recommended Books

- .. SP Mathur. Coal Mine Planning and Design. Geeta Book Store, Bilaspur.
- .. RD Singh. Principles and Practices of Modern Coal Mining. New Age International (P) Ltd., New Delhi.
- .. H L Hartman. Mining Engineering Handbook. SME AMIE, Littleton, Colorado, USA.
- .. JBhattacharya. Mine Planning. Allied Publishers Ltd., New Delhi.

MINE SURVEYING

(See page 82, subject MN 414)

MINE MANAGEMENT AND LEGISLATION

(See page, 82, subject MN 415)

The Birth of a New Concept

Perronet (1708-94), who made extensive time studies on the manufacture of brass pins, was a pioneer in production engineering. However, the concept of mass production started with massive projects embracing the efficiency of men, materials and organisation. H. R. Tonna (1884-1924) installed electric hoists, testing machines and cranes for quality production and reported his experience in a paper, read in 1886, on 'the Engineer as Economist' with an eloquent plea for the marriage of production and management. F W Taylor (1856-1915), a consultant on 'efficiency engineering', demonstrated that the capabilities of both men and machines could be measured, and by doing so, employer-employee relationship could be improved. After he published his Principles of Scientific Management in 1911, psychologists and engineers reinforced his findings. Current developments in cost accountancy and allied areas have been the extension of his concept.

The Pragmatic Approach to Transdiscipline

Advent of the machine age, backed by all-pervading scientific ideas, brought in new dimensions in technology ushering welfare to mankind. Pragmatic attention to the area of Production Engineering started nucleating only since the early decades of this century when Fredrick W Taylor laid the foundation of production studies. He gave birth to the concept of 'Production Engineering' by coupling 'Scientific Management' to 'Man-Machine' unit with a scientific attitude developed through a deep study of physical and natural sciences. Taylorism spread in the early twentieth century so much so that even V. I. Lenin urged introduction of the system in Russia in an article in Pravda on April 28, 1918.

Confronting the Indust-real World

Henry L Gantt utilised graphs and charts to analyse variations in sales and

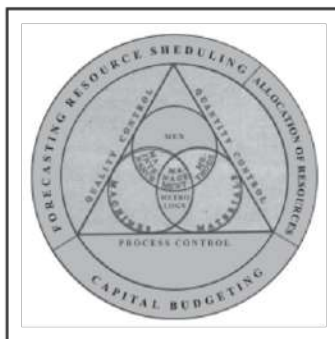
production and Carl G Barth developed a production sliderule. Another significant development was time and motion study, made by Frank B Gilbreth and his wife, published in a book *Motion Study* in 1911.

The complex manufacturing system involving planning and timely execution demanded making decisions based on mathematical models. This led to the emergence of operational research. This existed in rudimentary form even during the first world war when F W Lanchester and Edison wrote a memorandum on military and naval matters. However, the continued efforts of Prof JD Bernal, Sir S Zuckerman and JB Conant brought operational research to prominence from 1940.

Production Engineering—The Movement in India

Production engineering as a specialised and integrated elective group within the general feature of mechanical engineering was

introduced in the curriculum of Jadavpur University by the pioneering effort of Late Prof G C Sen, who was a direct disciple of Late Prof Arland and Late Prof O W Boston. Subsequently several institutions started similar programmes. Finally the first full-fledged degree course in production engineering was started in the Birla Institute of Technology, Ranchi. Since then a number of similar such programmes are now run in different engineering institutions, of which the Production Engineering Department of Jadavpur University started in 1978 remains in the lead.



Engineering That Cuts Across Every Discipline

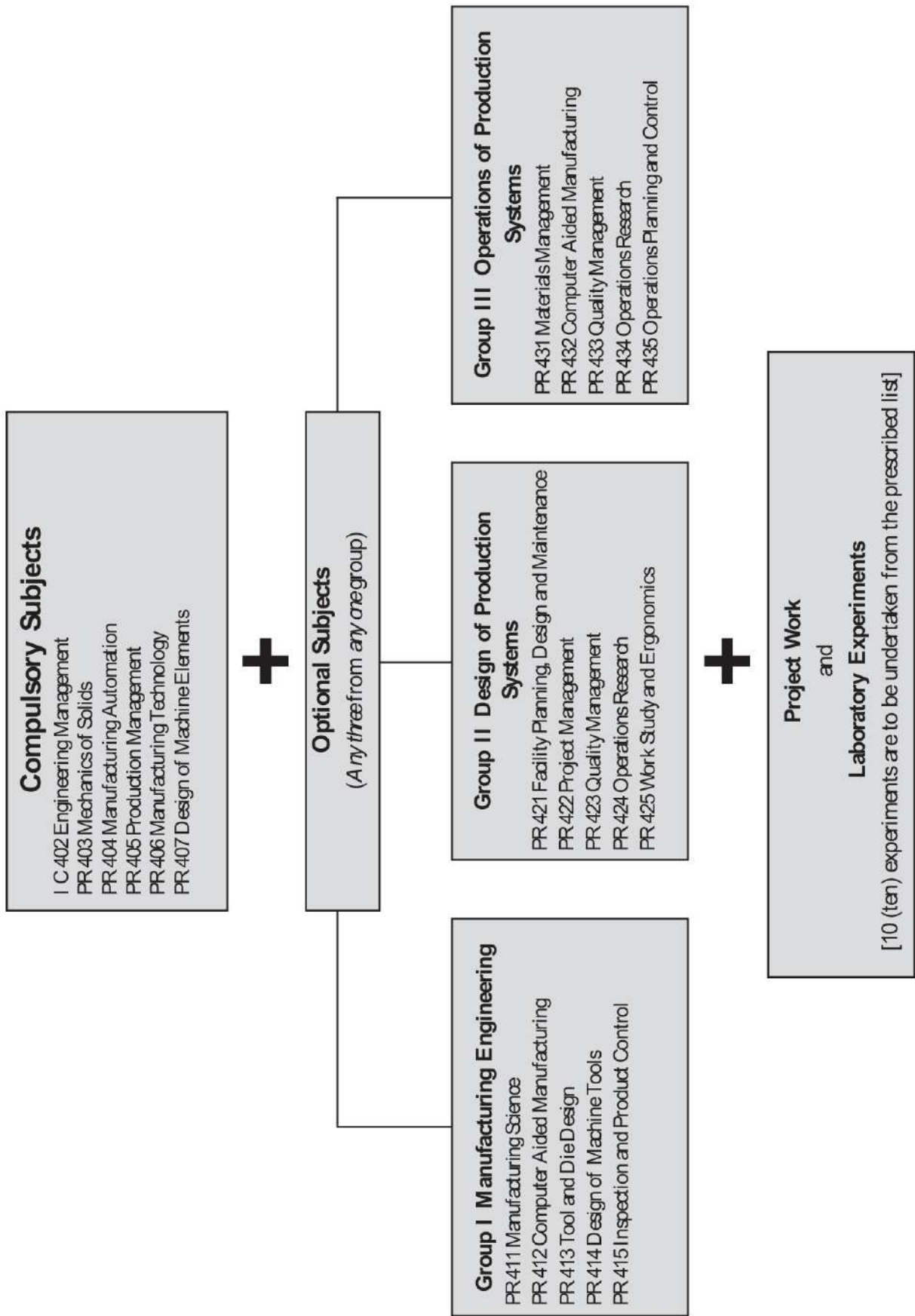
It is a multidisciplinary integrated study dealing with the process, methodologies and management for transforming and trans-shaping technologically a given set of inputs into a set of desired and deducible outputs based on synergic concepts through the optimum utilisation of human resources, goods and services.

Production Engineering coordinates search for knowledge in rational manner cutting across the entire spectrum of integrated management and processing activities to attain optimal economic objectives of sufficiency. It lays down a disciplined use of strategies for increased productivity with ensured quality and quantity.

Production means 'actions' to meet the material needs of the prime element – the man – of the society at right place and right point of time for meaningful sustenance of life. Technology is merely the tool for such actions. The multidimensional needs are only supported by the various engineering disciplines for food, habitat, clothing, environment, energy and communication. Production engineering is thus the thread of the garland of flowers – agricultural, civil and architecture, mechanical, electrical and electronics, metallurgy and mining, chemical and environment, textile, computer and telecommunications, marine and such others.

Another variation of this programme has, sometime back, been introduced at IIT, Kharagpur and this encompasses the specialization character of production engineering in the new semantics of 'manufacturing science'. A branch of production engineering has also emerged as 'industrial engineering' which covers the management aspects of production engineering, including OR, graph theory, etc.

PRODUCTION ENGINEERING



PRODUCTION ENGINEERING

IC 402

ENGINEERING MANAGEMENT

(See page 13, subject IC 402)

PR 403

MECHANICS OF SOLIDS

(See page 61, subject MC 403)

PR 404

MANUFACTURING AUTOMATION

(See page 68, subject MC 434)

PR 405

PRODUCTION MANAGEMENT

(See page 69, subject MC 435)

PR 406

MANUFACTURING TECHNOLOGY

(See page 62, subject MC 406)

PR 407

DESIGN OF MACHINE ELEMENTS

(See page 62, subject MC 407)

PR 411

MANUFACTURING SCIENCE

(See page 67, subject MC 431)

PR 412

COMPUTER AIDED MANUFACTURING

(See page 68, subject MC 432)

PR 413

TOOL AND DIE DESIGN

(See page 68, subject MC 433)

PR 414

DESIGN OF MACHINE TOOLS

(See page 66, subject MC 424)

PR 415

INSPECTION AND PRODUCT CONTROL

Group A

Introduction: Functions and responsibilities of inspection and product control department, organisation personnel—job specifications and inspection training programme.

Product and component specifications: Purpose, types of specifications, drawing up specifications, specifying tolerances, designations of critical dimensions, tolerance build ups in assembly, revision of specifications.

Inspection planning: Establishing the acceptable quality level, control charts, process capability.

Measurements and gauging: Nature of measurements, sensitivity and precision of measurements, limit gauging, gauge types and their use, Taylor's principle, wear allowance, gauge makers allowance, guidelines for the selection of fits, ISO system of limits and fits.

Dimensional measurements: Linear measurements, principles of selection and operation of linear measuring instruments. Comparators, interferometers, use of lasers in measurements.

Group B

Angular and profile measurements: Measurement of taper, calibration of circular dimensions, optical instruments for angular measurements, auto collimator, measurements of screws and gears.

Measurement of surface roughness: Surface properties, methods of surface finish measurement and analysis, roundness assessment, surface roughness measuring machines, operation and selection principles.

Measuring machines: Principles of automated and in process inspection, mechanical, hydraulic, optical, electromagnetic, and electronic devices. General principles of selection and operation of measuring machines, co-ordinate measuring machines (CMM).

Non-destructive testing and inspection: Introduction, scope of applications. Methods of non-destructive testing and their selection, magnetic particle inspection, X-ray examination, Gamma radiography, ultrasonic inspection of flaws in

manufactured parts, electric method, damping test, non-magnetic methods.

Interchangeability and selective assembly—their role in mass production.

Recommended Books

- .. W Grant and E L Grant. Handbook of Industrial Engineering and Management. Prentice Hall of India (P) Ltd., New Delhi.
- .. R K Jain. Engineering Metrology. Khanna Publishers (P) Ltd., Delhi.
- .. K J Hume. Engineering Metrology. McDonald & Co.
- .. I C Gupta. Engineering Metrology. Dhanpat Rai & Sons, Delhi.

PR 421

FACILITY PLANNING, DESIGN AND MAINTENANCE

Group A

Introduction. Facility planning, design functions and scope.

Facility location. The supply distribution system, location strategy, nature of location decision, location evaluation methods, single or multiple facility locations, choice of a site within a region, network location problems.

Design of plant or facilities. Factors in the design of plant or facilities, material handling and facility design layout.

Facility layout. Introduction, planning the layout, advantages of a good layout, analysis of a layout problems, patterns of flow, activity relationship chart-from-to-chart, layout procedures, Nadler's ideal systems approach, Immer's basic steps, Apple's plant layout procedure, systematic layout, planning, flow and activity analysis.

Types of layouts—fixed position layout. Product layout—line balancing methods, process layout, layout of work areas, group technology based layouts, layout problem and the assignment model.

Group B

Applications: General layout problems in storage, receiving and warehousing. Facility services and nonmanufacturing applications, computerised layout planning and evaluation (CRAFT and CORELAP), policy for location and layout of storage system.

Maintenance of facilities and equipment: Maintenance policies, data collection and analysis, periodic maintenance, total preventive maintenance, the maintenance unit, duties and planning for the routine maintenance programme, maintenance in operation, repair and replacement.

Recommended Books

- .. A Muhlemann, J Oakland and K Lockyer. Production and

Operations Management. Macmillan India Ltd., New Delhi.

- .. D R Sule. Manufacturing Facilities Location, Planning and Design. Standard Publishers & Distributors, Delhi.

- .. SN Chary. Production and Operations Management. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

PR 422

PROJECT MANAGEMENT

Group A

Introduction. Elements of project management, feasibility analysis, detailed evaluation of projects, analysis of technical feasibility, measurement of cost and benefit, cost/benefit analysis.

Planning and scheduling networks. Arrow diagram, dummy activities, activity-on-node diagram, Fulkerson's numbering algorithm, finding the critical path.

Critical path analysis. Job slack, early start and early finish times, late start and late finish times, total and free slack, project due date and earliest completion time, scheduling from a network, time costing methods—examples and applications. Lowest cost schedule.

Group B

The PERT model. Introduction, PERT's event orientation, PERT assumptions. The problem of uncertainty, expected times, variability of activity times, expected length of critical path, probability of project completion by a given due date, PERT/cost. A network cost accounting system.

Network scheduling with limited resources. Heuristic methods for resource scheduling, resource levelling program, resource allocation program.

Modifications and extensions of network models. Precedence network and algorithms, effect of job splitting, decision networks, introduction to probabilistic networks.

Recommended Books

- .. JD Weist and F K Levy. A Management Guide to PERT/CPM. Prentice Hall of India (P) Ltd., New Delhi.

- .. SN Chary. Production and Operations Management. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

PR 423

QUALITY MANAGEMENT

Group A

Introduction. Historical background, quality assurance, total quality assurance system, training and documentation, quality movement in India.

Standardisation for quality. Standards for quality, standards and quality objectives, quality levels and quality grading, national system of standardisation, ISO quality system and international certification.

Quality management. Management tools, affinity diagram, relation diagram, tree diagram, matrix diagram, arrow diagram, matrix-data analysis. Total Quality Management.

Quality circles. Introduction, quality circle operation, steps to sustain quality circle activities.

Quality audit. Purpose and requirements of audit, audit methods, guidelines for system audit.

Control charts and process capabilities. Theory of control charts, control charts for variables, process capabilities and specification, control charts for attributes, various types of control charts and their applications.

Group B

Sampling inspection. Inspection of attributes, aim of a sampling method, acceptance sampling, OC curves, single and multiple sampling plans and methods, sequential sampling, average outgoing quality, comparison of OC and average outgoing quality approaches.

Process design and improvements. Need for planned experimentation, planning for experiments, response surface methods, standard experimental designs, concurrent design, Taguchi method, tolerance design.

Reliability engineering. Quality and reliability, achieving reliability, redundancy, reliability prediction, fault tree analysis, worst case analysis, step stress testing, failure modes, effects and criticality analysis, life characteristics, design reviews.

Recommended Books

- .. M N Murthy. Excellence through Quality and Reliability. Applied Statistics Centre.
- .. M P Poonia. Total Quality Management. khannabooks.com. Khanna Book Publishing Co. Ltd.

PR 424

OPERATIONS RESEARCH

Group A

Introduction: Origin and nature of operations research, impact of OR on industrial decision making.

Linear optimization models: Problem formulation and solution procedures, simplex method, tabular form of simplex method, transportation and assignment problems, applications, duality and sensitivity.

Network models: Shortest route algorithm, critical path scheduling.

Theory of games: Competing situation. Two-person zero-sum games.

Group B

Dynamic optimization models: Principle of optimality, application examples.

Integer programming: Solution techniques (cutting plane algorithm), application examples.

Introduction to non-linear programming. Optimization with non-linear objective function with and without constraints (simple examples).

Queuing models. Taxonomy of queuing models, finite and infinite queues, single server model with Poisson input and exponential service. Applications.

Neural networks: Fundamentals, scope of application, different types/ categories.

Recommended Books

- .. H A Taha. Operations Research: An Introduction. Prentice-Hall of India (P) Ltd., New Delhi.
- .. J K Sharma. Operations Research: Theory and Applications. Macmillan India Ltd., New Delhi.
- .. H M Wagner. Principles of Operations Research with Applications to Managerial Decisions. Prentice-Hall of India (P) Ltd., New Delhi.

PR 425

WORK STUDY AND ERGONOMICS

Group A

Introduction. Scope of motion and time study, productivity and work-study.

Method study. Various tools used in method analysis, recording techniques, charts and symbols, operation process chart, flow process chart, two-hand process chart, multiple activity chart.

Motion economy. Rules for motion economy (related to use of body, arrangement of work place, tools and equipment, etc.).

Method development. Tools, work simplification programme.

Micro motion study. Fundamental hand motions, micro motion study equipment, simo chart and memo motion study.

Work measurement. Concept and theory of work measurement.

Time study. Timing of work elements, error in time study, operation sheets.

Work sampling. Theory of work sampling, determination of standard time.

Group B

Standard time. Performance rating systems, objective rating, rating of skill and effort, synthetic rating, rating factor and

allowances, computation of standard times, examples and applications.

Predetermined motion time systems. Motion time measurement (MTM), development of MTM, application methodology, simplified MTM.

Work factor. Work factor system, principle and variables, introduction of work factor, comparison with elemental time standards.

Job evaluation and merit rating. Job evaluation methods, selection of evaluation plan, job rating, merit rating—types and methods.

Wages and incentives. Real and money wages, incentive types, incentive plans, incentives for indirect labour, operating cost of incentive schemes.

Ergonomics. Introduction and scope, human abilities, human factor considerations, machine systems, measurement of human performance, design considerations for man-machine systems, ergonomics and work study.

Recommended Books

.. S Datta. Elements of Work Study. Standard Publishers & Distributors, Delhi.

.. E W McCormick. Human Factors in Work Design. Prentice-Hall of India (P) Ltd., New Delhi.

.. Introduction to Work Study. An ILO Publication (Indian edition). Oxford & IBH Publishing Co. (P) Ltd., New Delhi.

PR 431

MATERIALS MANAGEMENT

Group A

Introduction. Importance of materials management, definition and scope.

Corporate policy and materials management. General corporate policy, concept of MBO, make or buy, quality and quantity requirements, cost aspects.

Organisation and control. Materials management in overall organisation, organising materials management, special requirements, interdepartmental relationships, materials research.

Materials planning and budgeting. Importance, techniques and guidelines, budgeting, ABC analysis, codification and standardisation, source selection.

Purchasing management. Creative purchasing, purchase systems, price forecasting, buying seasonal commodities, purchasing under uncertainty, purchase of capital equipment, international purchasing, import substitution, public buying, legal aspects of buying, buyer seller relationships.

Warehousing and stores management. Location and layout

of stores, stores management, system and procedures, incoming materials control, stores accounting and stock verification, scrap management, value engineering, materials handling and transportation.

Group B

Inventory management. Relevant inventory related costs, economic ordering quantity, static risk model, dynamic-certain model, cost sensitivity analysis, practical inventory systems, system design, safety stock, Q-system, P-system, optional replenishment system.

PERT and OR techniques in materials management, application of computers in integrated materials management systems, materials requirement planning.

Value engineering. Origin, applications and impact.

Evaluation of materials management functions. Organisation, process and criteria. Index ratios.

Recommended Books

.. P Gopalakrishnan and M Sundaresan. Materials Management—An Integrated Approach. Prentice-Hall of India (P) Ltd., New Delhi.

.. M P Poonia. Total Quality Management. Khanna Book Publishing, New Delhi.

PR 432

COMPUTER AIDED MANUFACTURING

(See page 68, subject MC 432)

PR 433

QUALITY MANAGEMENT

(See page 89, subject PR 423)

PR 434

OPERATIONS RESEARCH

(See page 90, subject PR 424)

PR 435

OPERATIONS PLANNING AND CONTROL

Group A

Introduction. Operations and operations manager, manufacturing and service operations, production/ operations functions and the organisation.

Analysis for operations management. Production/ operations strategy, guides to creating POM strategy and utilities, trade-off analysis, models in operations management. Break-even and investment analysis.

System planning and design for operations. Long range planning and system design, operational planning and control, marketing considerations in the design of operations, interface with personnel, finance and engineering, forecasting and long range planning

Forecasting methods. Forecasts based on subjective opinion, index and averages, statistical methods, moving average and trend forecaster, exponential smoothing, evaluating and controlling the forecasts, information requirements and forecasting

Intermediate range planning and scheduling. Introduction, planning horizon, aggregate planning, rules for aggregate planning, production smoothing, rolling schedules, backlogging demand, plan development—graphical method, plans with varying production rates, developing alternative plans, aggregate planning by linear programming

Group B

Inventory control: Introduction, independent and dependent demand, inventory replenishment policies, the economic order quantity (EOQ), adapting EOQ to fit the real

situation, safety stocks.

Production scheduling and job shop control. Economic production quantity, lot sizing, scheduling with limited capacity, facility cycle scheduling method, capacitated lot-size heuristics, planning the use of several productive units, Gantt charts and scheduling, despatching and information flow in job shops—examples.

Multistage production systems: Planning in multistage systems, capacity planning, materials requirement planning, master scheduling and MRP-II, JIT production systems.

Supply chain management: Introduction, relevance. Simple models.

Recommended Books

- .. J O McClain and L J Thomas. Operations Management. Prentice-Hall of India (P) Ltd., New Delhi.
- .. A Muhlemann, J Oakland and K Lockyer. Production and Operations Management. Macmillan India Ltd., New Delhi.
- .. SN Chary. Production and Operations Management. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

The Fragile Yarn—Skillful Achievements

Florance, by manufacturing her own cloth, became a reputed industrial town in the Fifteenth Century. Growth of Florance helped development of banking and academics. Invention of the steam engine and the spinning machine by Arkwright helped establishment of the first textile mill in 1771.

Subsequently, Kay's flying shuttle and Hargreave's Spinning Jenny enabled yarn to be produced to keep pace with demand. Crompton imparted fineness to the yarn and Cartwright and Harrook improved spinning. Coal production also had to be increased to feed the boilers of steam engines for the cotton mills. Benjamin Gott established a factory in 1792 to apply cotton textile techniques to the woollen industry.

Work on the development of manmade fibre by Edison, Swan, Hyatt, Stearn, Topham, Cross and Bevan resulted in the production of 'viscose' in 1892 by Courtaulds. Topham invented spinning of such viscose fibres.

Indian Textile—Pride of Centuries

Even in ancient times, Indian textiles were famous the world over for colour and quality. The origin of the mechanised cotton textile industry, in India, dates back to 1818 when the first cotton mill was established at Fort Gloster, near Kolkata. The *Swadeshi Movement* enabled the industry to make rapid strides. Similarly, the jute industry, a major foreign exchange earner, was born when the first power-driven jute mill was established at Rishra near Kolkata in 1859.

The textile industry occupies a position of pride

amongst organised industries. Mumbai, Ahmedabad, Sholapur, Kanpur, Nagpur, Indore, Madurai, Coimbatore, etc. are the main centres. In the small scale sector too, millions of people living in rural areas are engaged in the production of textiles. India earns a reasonable foreign exchange from export of textile goods. A number



Carding Machine

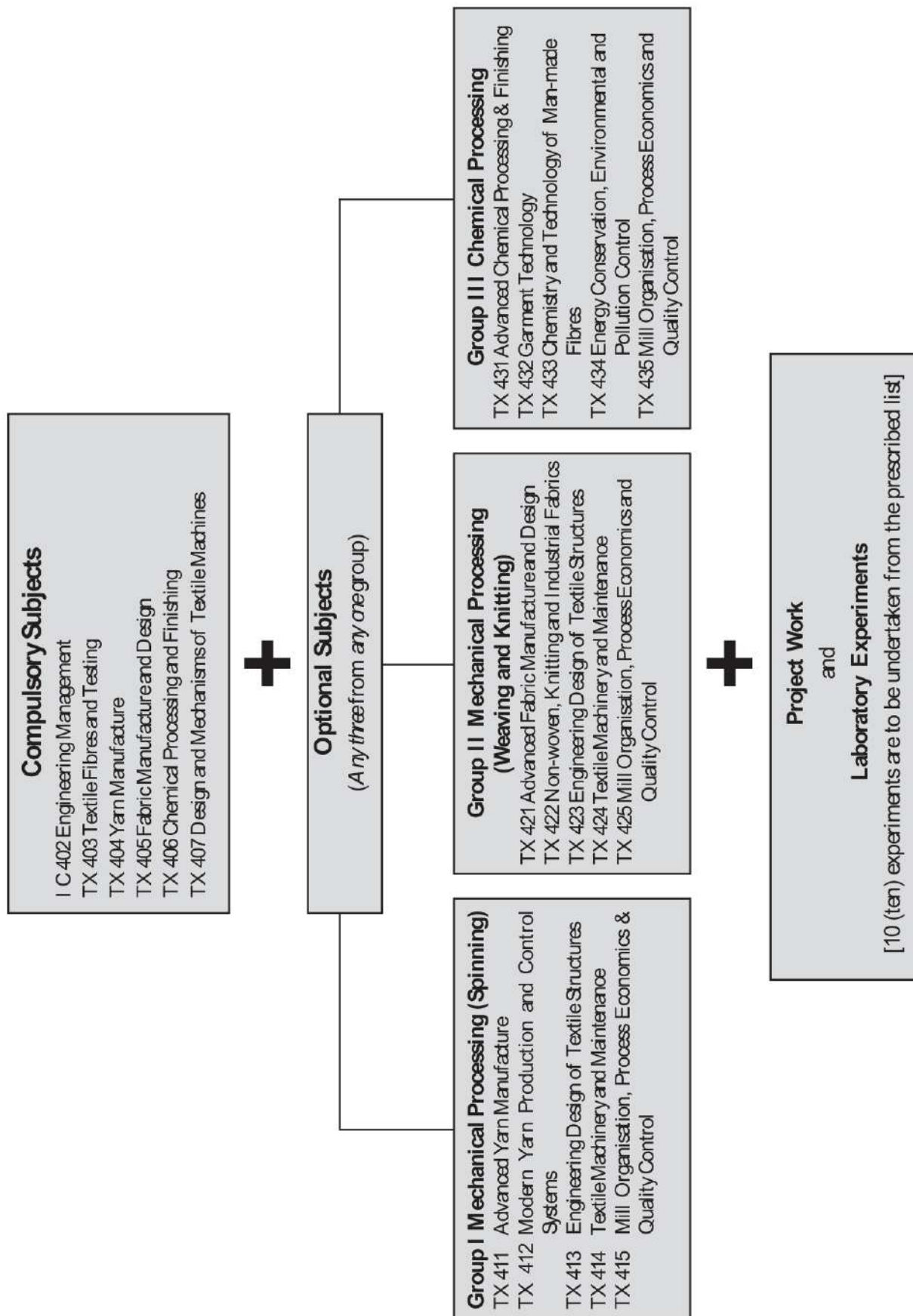
Textile engineering is concerned with the processing of natural fibres (cotton, silk, wool, jute, coir, flax, sisal, manila, hemp, etc.); synthetic and/or man-made fibres (nylon, terylene, orlon, vinyon, velon, rayon, acrylic, etc.) and other fibres (made from glass, etc. but not metallic) in appropriately designed machines relevant to the type of fibre (to be processed) to produce yarns (ply, core and covered), fabrics for general and lustrous clothings, furnishing and decorative fabrics, packaging and industrial fabrics, special textile (for use in hospital, parachute, filtration, etc.), knitted and non-woven fabrics, ropes, geotextile, etc. The design of textile machinery, dyeing of yarn, printing of cloths, production of garments – all these facets come under the purview of textile engineering to certain extent.

of government departments, research organisations, educational institutions and co-operatives are actively involved to further the industry. When Slater's version of the Arkwright machinery was set up in Ezekiel Carpenter's mill, a maddening problem developed. One of the two carding machines began rolling up fibers into a massive tangle instead of delivering them in a roll for the drawing and roving machines. Slater uttering deep sighs was frequently shedding tears. Those present asked, 'Art thou sick, Samuel?' He explained his problem, adding, 'If I am frustrated in my carding machine, they will think me an imposter'. The trouble was that Pliny Earle's experience was with hand cards, and he did not fully realize that a different technique was necessary for the machine!



Cotton Carding Machine

TEXTILE ENGINEERING



TEXTILE ENGINEERING

IC 402

ENGINEERING MANAGEMENT

(See page 13, subject IC 402)

TX 403

TEXTILE FIBRES AND TESTING

Group A

Classification of textile fibres according to their nature and origin. Geographical distribution, growth.

Cultivation, grading, physical and chemical structures.

Properties and uses of natural fibres such as cotton, flax, jute, silk and wool.

Brief outline of the process involved in the conversion of these fibres into yarn.

Brief outline of manufacturing processes of important man-made fibres (rayons, polyamides, polyesters and acrylics).

Chemical nature of man-made fibres.

Methods of producing fibres by wet, dry and melt spinning processes.

Properties and uses of important man-made fibres.

Group B

Sampling techniques for testing of fibres, yarns and fabrics.

Measurement of fibre length and fineness.

Principle and operation of various equipment for measuring moisture regain in textile materials.

Measurement of twist and linear density of yarn.

Evenness testing of slivers, rovings and yarns.

Principles of operation of CRL, CRT and CRE tensile testing machines for fibres, yarns and fabrics.

Methods of testing fabric thickness, weight, shrinkage, stiffness, drape, tear resistance, abrasion resistance, bursting strength, air permeability and crease recovery.

Recommended Books

- o J E Booth. Principle of Textile Testing. CBS Publishers & Distributors, New Delhi.
- o W E Morton and J W S Hearle. Physical Properties of Textile Fibres. Textile Institute, UK.
- o J E Booth. Textile Mathematics—Vols: 1, 2 & 3 Textile Institute, UK.
- o Meredith and Hearle. Physical Methods of Investigating Textiles. Interscience Publishing Co., New York.
- o B C Goswami. Textile Yarn. Mahajan Book Distributors, Ahmedabad.

TX 404

YARN MANUFACTURE

Group A

Mixing, opening and cleaning: Bin mixing and mixing by automatic blenders, construction and working of machines of single process blow-room line.

Different types of conventional feeders, openers and cleaners.

Use of air currents for cleaning and transportation, blow-room sequences for different natural and man-made fibres.

Carding: Principles and objects. Construction and working of conventional revolving flat card. Settings of various parts of the card. Maintenance of cards. Flexible and metallic card clothing.

Drawing: Objects of doubling and drafting. Construction and working of conventional draw frame. Roller weighting and setting. Stop motions, sliver irregularity, drafting wave, roller slip, etc.

Combing: Objects, construction and working of conventional sliver lap and ribbon lap machines and Naamith comb, settings and maintenance of comb.

Group B

Speed frames: Objects, construction and working of conventional flyframes, twisting, winding and building mechanisms. Speed and settings to suit different fibres. Stop motions.

Spinning: Construction and working of conventional ring frame. Ring and traveller assembly. Spindles, building motions, etc. Specification of ring frame to suit different counts. Brief description of mule, cap and pot spinning frames.

Reeling, bundling and baling: Different forms to which yarns are converted for marketing. Brief study of machines used.

Doubling: Preparation of yarn for doubling. Manufacture of various types of folded and cabled yarns. Yarn finishing. Sewing thread and various fancy yarns.

Yarn preparation and methods of yarn conditioning. Calculations pertaining to the machines and products dealt within the process.

Recommended Books

- o E Oxtoby. Spun Yarn Technology. Butterworths, London.
- o K R Salhotra. Spinning of Man-made and Blend on Cotton System. Textile Association, Mumbai.
- o P R Lord. Spinning in the Seventies. Merrow Publications, England.
- o W Klein. Manual of Textile Technology—Vols: 1-6. Textile Institute, Manchester, UK.
- o Manual of Cotton Spinning. Textile Institute, Manchester, UK.

FABRIC MANUFACTURE AND DESIGN

Group A

Various systems of yarn preparation and their functions. Details of non-automatic winding machines of all types. Winding faults and remedies. Uses and limitations of slow-speed winding machines. Essentials of automatic cone and cheese winding machines. High speed winding machines—B C spoolers, rotoconers, Schlathorst auto-coner, unicoer, etc. Precision winding.

Beam and sectional warping processes and mechanisms. High speed warping, planning of patterned warps.

Prin winding. High speed prin winding machines—schweiter, hacoba, scharer, auto-copser, etc. Bunch building mechanisms.

Study of all types of sizing machines. Sizing ingredients, sizerecipes for different materials. Control of size pick-up. Slasher speed and drying efficiency. Sizing waste and stretch control.

Methods of drawing in, twisting and knotting.

Group B

Classification of loom mechanism as primary, secondary and auxiliary motions. Detailed study of plain and automatic powerlooms. Various ways of shedding and kinds of sheds. Various methods of picking: under, over and crankshaft picking—their merits and demerits. Beating-up. Eccentricity of the sley and its effect on loom working. Shuttle/ prin changing, take-up and let-off motions in detail. Side welt fork motion. Loose reed and fast-reed warp protecting motions. Timing and setting of various motions.

Mechanisms of different types of negative and positive dobbies including cross-border, paper and cam types. Multiple box motions. Pick-at will motions.

Calculations pertaining to the above machines and products dealt within the process.

Fabric classification and weave notation. Plain weave, its variations and ornamentation. Ordinary and steep twills. Twill derivatives—pointed, broken, combination, diamond.

Twills, herring-bone and twill checks. Satin weaves and satin derivatives. Simple colour and weave effects. Woven stripes and checks. A brief and general study of Jacquard and shuttleless weaving.

Constructional particulars of various types of fabrics produced, employing the weaves studied. Computer-aided design and manufacture of textile structures.

ISI standards for important mill-made and handloom fabrics using different materials.

Recommended Books

- o R Sengupta. Yarn Preparation. The Popular Book Depot, Mumbai.

- o M K Talukdar. An Introduction to Winding & Warping.
- o PK Banerjee. Yarn Winding. NCUTE, IIT, New Delhi.
- o Mark and Robinson. Principles of Weaving. Textile Institute, Manchester, UK.
- o M K Talukdar, et al. Weaving Machine Mechanics and Management. Mahajan Book Distributors, Ahmedabad.
- o V Duxbury and CR Wray. Modern Development in Weaving Machinery. Columbiere Press, Derbyshire.
- o O Talavasek and V Svaty. Shuttleless Weaving. Elsevier Scientific Publishing Co., New York.
- o A Armored. Weaving Technology and Operation. Textile Institute, Manchester, UK.

CHEMICAL PROCESSING AND FINISHING

Group A

Principles of fabric preparation. Introduction to various wet-processing treatments such as de-sizing, scouring, bleaching and after-treatment processes.

Surface agents—its mechanism and application, etc.

Procedure for application of various dyes as natural and man-made fibres and after-treatment dyes. Methods and styles of printing and printing procedure of different fibres; fabrics with various classes of dyes and after-treatment processes.

Group B

Principles of finishing of natural, man-made fibres and blended fabrics. Classification of various finishes. Finishing materials—their functions and applications. Permanent and semi-permanent finishes like mercerised wash-n-wear, crease-resistant, anti-shrink, water-repellent rot and mildew-proofing and flame-proofing finishes. Organidie, crabbing, milling and decasting of wool, fabric coating, scroopy finish of silk, weight reduction of polyester, etc.

Setting of synthetic fabrics by dry heat and steam and their effect on physical and chemical properties.

Introduction to finishing machines such as scutchers, mangles, drying ranges, hot air dryers, stenters, calenders, raising, craping, plating and pressing machines.

Recommended Books

- o E R Trotman and B I Griffin. Chemical Technology of Scouring and Bleaching. B I Publications, New Delhi.
- o E R Trotman and B I Griffin. Dyeing and Chemical Technology of Textile Fibres. B I Publications, New Delhi.
- o Technology of Bleaching/ Dyeing/ Printing/ Finishing. Savak Publication, Mumbai.
- o A Vaidya. Textile Auxiliaries and Finishing. ATIRA, Ahmedabad.
- o Sadov Matsky. Chemical Technology of Fabric Materials. Mir Publications, Moscow.

DESIGN AND MECHANISMS OF TEXTILE MACHINES

Group A

Effectiveness of different openers and cleaners in blowroom line. Study of the principles in designing modern openers and blenders.

Study of metallic wires in cards. Complete study of the design of high production cards. Different approaches in evaluating carding performance. Design improvements in licker-in zone and feeding mechanisms.

Theories of drafting mechanism of hook removal during drafting. Principles of auto-leveller. Principles of winding in fly frame. Improvements in the design of high speed fly frames.

Principle of winding in ring frames. Effect of friction on ring and traveller wear. Design of ring and travellers. Optimum package size. Causes of end breakages on ring frame. Design improvements in high speed ring frame. Automated spinning systems.

Group B

Study of the principle, design and operation of modern winding, warping and sizing machines. Theory and design principles of latest automatic controls in sizing.

Principles governing the design of looms. Mechanics of basic weaving operations. Kinematics of sley, heald motion and shuttle motion on conventional looms. Design problems of conventional weaving.

Principles underlying non-conventional weaving machinery designs. Kinematics of weft propulsion in nonconventional weaving machinery.

Design features of dust control units used in textile mills.

Recommended Books

- o K Slater. Textile Mechanics—Vols. 1 & 2. Textile Institute, Manchester, London.
- o W A Hanton. Mechanics for Textile Students. Textile Institute, Manchester, London.
- o P Grossberg. An Introduction to Textile Mechanics. Ernest Benn Ltd., London.
- o T Bevan. Theory of Machine Designing. Longmans Green & Co., New York.

ADVANCED YARN MANUFACTURE

Group A

Opening machinery. Modern developments, latest blending techniques, aerodynamic study of opening and cleaning action of blow-room machinery.

Carding. Theoretical treatment of the fibre configuration in card sliver. Intensity of carding. Fibre loading on wire surface and transfer efficiency of card.

Drawing. Theories of drafting. Modern drafting systems for drawn frames. Auto-levellers and their performance. Modern high-speed draw frames.

Combing. Effect of hook formation in carding on lap preparation methods. Superlap former. Modern high speed combers and post-combing processes.

Speed frames. High twist rovings and high speed flyers, modern speed frames.

Spinning. Study of yarn tension and twist flow in ring spinning. Use of variable speed drive for ring frames. Modern ring frames, end breakages in ring spinning—causes and control. Limitations of ring frame spinning.

Group B

Man-made staple fibre spinning. Modification of spinning machinery for processing man-made fibres and their blends with cotton and other natural fibres.

Effect of fibre characteristics and processing parameters on yarn properties. Yarn hairiness.

Study of blended yarns and their properties. Structure and properties of staple spun yarns.

Yarn irregularities. Classification of yarn irregularity. Effect of processing and fibre parameters on irregularity of yarn. Effect of yarn irregularity on fabric appearance.

A brief study of non-conventional spinning methods.

Recommended Books

- o E Oxtoby. Spun Yarn Technology. Butterworths, London.
- o K R Salhotra. Spinning of Man-Made and Blend on Cotton System. Textile Association, Mumbai.
- o P R Lord. Spinning in the Seventies. Merrow Publications, England.
- o W Klein. Manual of Textile Technology: Vols 1-6. Textile Institute, Manchester, UK.

MODERN YARN PRODUCTION AND CONTROL SYSTEMS

Group A

Tow conversion processes

Introduction to the texturing of man-made fibre yarns. Study of twist-set-untwist, false twisting edge, crimping, stuffer-box crimping and air bulking processes of producing textured yarns.

Properties and application of textured yarns.

Causes leading to advent of open-end spinning. Study of drum, air-vortex and electrostatic spinning techniques for the formation of break-spun yarns. Quality of break-spun yarns.

Studies of yarn formation by air jet and friction spinning.

Yarn characteristics Effect of different parameters on processing and yarn properties.

Methods of production of self-twist and twistless yarns, their properties and applications.

Production of industrial yarns such as core-spun, tyre cord, monofilament and tape yarns.

Modern processes for texturing/ bulking/ intermingling. Modern process for tow to top conversion. Modern machines and processes for staple fibre yarn manufacture.

Group B

Transport of material in the blow-room. The need for transport, mechanical transport, pneumatic transport; control of material flow in B R—classification, optical regulation systems in stop—80 operation, continuous operation; Accessories and associated equipment—metal extractors, fire eliminators, waste disposal; Recycling—economy of raw material, quality of waste material, the recycling installation, on-line and off-line systems.

Auto-levelling at cards. Basics, classification, principles of short-term, medium-term and long-term auto-levelling; measuring devices; auxiliary equipment—suction dust removal on high performance cards, waste disposal.

Monitoring and auto-levelling in drawframe. Classification of monitoring systems, monitoring devices with self-compensation and auto-levelling; classification of auto-levelling systems, evener drawframe with open loop, closed loop and combined control; correction length, evening operation.

Monitoring devices in speed frame. Need for such devices—sliver stop motions, roving stop motions, blower apparatus. Novel features of a modern speed frame and automation.

Automation and ancillary equipment in frame. Need for automation, possibilities for automation, end break aspirators, piecing devices, roving stop motions, travelling clearer; monitoring—purpose, computer-based data collection system; automatic cop treatment.

Recommended Books

- o E Oxtoby. Spun Yarn Technology. Butterworths, London.
- o K R Salhotra, Spinning of Man-made and Blends on Cotton System. Textile Association, Mumbai.
- o P R Lord. Spinning in the Seventies. Merrow Publications, England.
- o W Klein. Manual of Textile Technology—Vols. 1-6. Textile Institute, Manchester, UK.

TX 413

MECHANICAL BEHAVIOUR OF MATERIALS

Group A

Yarn geometry—idealized yarn geometry; relationship of yarn number and twist factor.

Yarn diameter, methods of measurement.

Packing of fibres in yarn—ideal packing. Hexagonal close packing and other forms. Packing factor and its measurement.

Twist contraction, limit of twist.

Variation of fibre extension and analysis of tensile forces for low extension of continuous filaments.

Fibre migration—mechanism of migration, condition for migration to occur; frequency of migration, migration in blended yarns.

A qualitative view of spun yarn mechanics—traditional and modified qualitative approach.

Group B

Elements of fabric geometry: Cloth setting theories. Pierce's equations and later modifications—relation of fabric properties to simple geometry, crimp interchange in woven fabrics, cover factor, weight factor, etc.

Classification of fabrics and streamlining the construction of fabrics based upon engineering design to achieve desired end-user requirements.

Application of engineering principles to product development.

Knit fabric geometry: Weft and warp knit fabrics.

Recommended Books

- o J W Shearle, P Grosberg and S Backer. Structural Mechanics of Fibres, Yarns and Fabrics Wiley Interscience, New York.
- o B C Goswami, J G Matrindale and F L Sardino. Textile Yarns Mahajan Book Distributors, Ahmedabad.
- o A T C Robinson and R Marks Woven Cloth Construction. Textile Institute, Butterworths, London.
- o F T Pierce Cloth Geometry. Textile Institute, Manchester, UK.

TX 414

TEXTILE MACHINERY AND MAINTENANCE

Group A

Basic kinematics: Links, pairs, higher and lower pair, chains. Mechanisms and inversions of mechanisms. Velocity and acceleration diagrams of linkages of four bar and slider-crank mechanisms; relative velocity method and instantaneous centre method.

Friction: Cone and collar friction—friction in single and multiple clutches—friction in cone clutch, power absorbed and transmitted in clutches of above types.

Belt and rope drives. Selection of flat belts. V Belts and ropes. Effects of centrifugal and initial tension. Horsepower transmitted.

Cams. Types of cams and followers. Cam profiles for constant velocity, simple harmonic motion and constant

acceleration of followers. Study of tangent and convex constant.

Determination of speed ratios in simple, compound and epicyclic gear trains.

Designs of cone drums for scutchers and speed frames. Roller weighing at different stages of spinning. Inertia of a carding engine. Differential motions used in speed frames. The theory of spinning balloons. Yarn tension in ring spinning, power requirements at various stages of spinning.

Preventive and on line maintenance.

Group B

Mechanics of winding and tension variations in winding.

Mechanics of various mechanisms of weaving machines.

Simple harmonic motion. Balancing of revolving masses. Designing of shedding and picking tappets.

Velocity of shuttle during acceleration and retardation. Picking force and the study of sley eccentricity.

Warp tension and its measurement.

Power requirement for different weaving motions.

Plant maintenance. Introduction, objects of plant maintenance, importance of plant maintenance, duties, functions and responsibilities of maintenance department, organisation of maintenance department, types of maintenance, breakdown maintenance, scheduled maintenance, preventive maintenance, predictive maintenance, maintenance schedule, maintenance of plant machinery.

Recommended Books

- o K S Slater. Textile Mechanics—Vols. 1-3. Textile Institute, Manchester, UK.
- o W A Hanton. Mechanics for Textile Students. Textile Institute, Manchester, UK.
- o P Grossbar. An Introduction to Textile Mechanics. Ernest Benn Ltd., London.
- o J E Booth. Textile Mathematics—Vols. 1-3. The Textile Institute, Manchester, UK.
- o V Svaty and O Talavšek. Shuttleless Weaving. Elsevier Scientific Publishing Co., New York.
- o Maintenance in Textile Mills. ATIRA Publication, Ahmedabad.

TX 414

MILL ORGANISATION, PROCESS ECONOMICS AND QUALITY CONTROL

Group A

Concept of control in production, measurement organisation, product development and design.

Classification and standardization of products and materials.

Production planning and control, plant layout. Work study, work measurement, wages and labour incentives. Costing and cost analysis. Economics of textile processes. Plant services.

Production planning and machinery balancing. To acquaint with production rates, waste and efficiency levels of good and progressive textile mills. To determine the number of machines required to produce desired quantities of end products (yarns and fabrics) taking into consideration the production rate of machines in different departments, efficiency, losses and waste levels and important processing parameters like hank, draft twist multiplier, counts, settings, etc. used at different stages of manufacturing.

Staffing of departments. Labour allocation in different departments of a textile mill. Workload standards for card tenters, speed frames and ring tenters, winders, doffers, weavers, etc., in terms of tripartite agreements and labour laws.

Group B

Process economics. Economics of large package spinning and short-cut processes. Optimum package size. Economics of high production carding and drawing their cost structures. Process-wise costing including case studies.

Economics of open-end spinning.

Economics of superspeed automatic warp and weft winding machines. Economics of various labour saving mechanisms mounted on automatic looms like 'box loader' and 'unfil' systems. Economics of various labour saving mechanisms mounted on automatic looms like 'box loader' and 'unfil' systems. Economics of shuttleless looms like sulzer, air-jet, water-jet, rapier looms, etc. Comparative economics of knitted and woven structures.

Process economics of wet processing.

Quality control: General notions, basic concepts of industrial quality control, connection with the theory of statistical tests.

Methods of rapid calculation, arithmetical mean, standard deviation.

Control charts, general notions. Practical construction of control charts, efficiency of a control chart, application to control of various characteristics.

Acceptance inspection plans, general notions, the operating characteristic curve, acceptance inspection by variables, acceptance inspection by attributes, double and multiple inspection plans, sequential plans.

Recommended Books

- o H B Menord. Industrial Engineering Handbook. McGraw-Hill International.
- o O P Khanna. Industrial Engineering & Management. Dhanpat Rai and Sons, Delhi.
- o Bethel, Alwater, Smith and Stackman. Industrial Organisation and Management. McGraw-Hill International.
- o A Ormerod. Management of Textile Production. Newnes Butterworth, London.
- o Mario Bona. Statistical Methods for the Textile Industry. TEXILIA.

ADVANCED FABRIC MANUFACTURE AND DESIGN

Group A

Various types of terry motions. Centre selvedge and leno motions. Classification of jacquards. Single lift single cylinder, double lift double cylinder, cross border, line pitch, inverted hook and leno jacquards. Card cutting and card lacing. Various types of harness ties and their mounting. Casting out of harnesses.

Conventional automatic looms and modern automatic looms, study of special motions and attachments—their timings and settings for proper functioning. Bobbin loader and unifil loom winder attachments.

Mechanical principles of the sulzer weaving machine. Picking, beating-up, selvedge formation and shuttleless weaving with more than one weft.

Air-jet weft insertion with special reference to the Maxbo loom—essential requirements, shedding, weft measuring, weft-tensioning, beating-up, weft gripping, weft cutting, weft-stop motion, and selvedge formation.

Weft insertion by water-jet, general description of the water-jet looms, weft supply system, tension device, measuring device, operation of the weft-supply system, considerations in the system. Fundamental problems of hydraulic weft insertion.

The rapier system of weft insertion, weft control mechanism, special features of weft control system, general timing system, beating-up, cloth take-up motion.

Circular looms and their mechanisms, functions and utility.

Group B

Diamond mock-leno, ordinary honeycomb, brighton honeycomb, huckaback, derivatives of mat, hopsack and crepe weaves; reversing weaves and designs giving stripes and checks.

Simple and wadded bedford cords, wefts and piques. Figured pique fabrics. Principles of figuring with extra materials. Distorted thread effect. Extra warp figuring, extra weft figuring. Figuring with extra warp and extra weft. Limitation of extra thread effects. Weft backed cloths. Warp backed cloths. Interchanging figured backed fabrics. Backed cloths with wadding threads. Limitation of backed cloths. Sett, stitched double cloths. Centre stitched double cloths. Interchanging double twill and sateen stripe designs. Cut effects in interchanging double cloths. Treble cloths. Multiple belting structures. Figured interchanging double cloths, figured interchanging treble cloths.

Damasks, brocades and tapestries. Stitched figuring weft constructions. Simple and fancy terry pile structures. Warp pile fabrics produced with the aid of wired and on the face-to-face principle. Weft pile fabrics. Gauge and leno structures. Madras muslin.

Construction of draft, peg and denting plan of the above designs.

Constructional particulars of different types of fabrics produced using the above structures. Colour theories. Study of various stages involved in the development of design. Historic and applied design. Designing for woven and printed fabrics.

Recommended Books

- o W Fox. Weaving Mechanism. Universal Publishing Corporation, Mumbai.
- o M K Talukdar, et al. Weaving Machine Mechanism and Management. Mahajan Book Distributors, Ahmedabad.
- o Ormerod. Weaving Technology and Operation. Textile Institute, Manchester, UK.
- o V Svaty and O Talavasek. Shuttleless Weaving. Elsevier Scientific Publishing Co., New York.
- o W Watson. Textile Design and Colour. Longmans Greens Co., London.
- o Z J Grosicki. Watson's Textile Design and Colour. Newnes-Butterworth, London.
- o Z J Grosicki. Advanced Textile Design. Newnes-Butterworth, London.

NON-WOVEN, KNITTING AND INDUSTRIAL FABRICS

Group A

Modern fabric production. Modern trend in the production of woven fabrics and evaluating the performance of different methods of production.

Classification of non-woven fabrics. A survey of the non-woven field—its uses and future growth. Principles of web formation. Fibre properties and their influence on properties of non-woven fabrics. Web geometry—fibre orientation, curl factor and web density—their effect on properties of non-woven fabrics.

Classification of binders and methods of binder application. Binder properties and effect of binder-fibre adhesion on properties of non-woven fabrics.

Principles of needle-bonded fabrics, their manufacture and properties. Spun-bonded and split-film fabrics.

Group B

Introduction to the manufacture and properties of industrial and knitted fabrics. Geometry of knitted structures.

Knitting. Warp and weft knitting, single jersey, double knit, interlock rib, raschel and tricot, structures and machines for knitting.

Industrial fabrics, coated fabrics, technical textiles.

Recommended Books

- o J Lunenschloss and W Albrecht. Non-woven Bonded Fabrics. Ellis Horwood Ltd., England.

- o RKroma Manual of Non-woven Fabrics Textile Trade Press, Manchester, UK.
- o J A Smirfit. An Introduction to Weft Knitting. Merrow Publishing Co. Ltd., London.
- o D Spencer. Knitting Technology. Pergamon Press, USA.
- o Ajgaokar. Knitting Technology. Universal Publishing Corporation, Mumbai.

TX 423

ENGINEERING DESIGN OF TEXTILE STRUCTURES

(See page 98, subject TX 413)

TX 424

TEXTILE MACHINERY AND MAINTENANCE

(See page 98, subject TX 414)

TX 425

MILL ORGANISATION, PROCESS ECONOMICS AND QUALITY CONTROL

(See page 99, subject TX 415)

TX 431

ADVANCED CHEMICAL PROCESSING AND FINISHING

Group A

Classification of surface active agents, its properties and various applications in wet processing, chemistry, mechanics and theories of wetting agent, detergents, levelling and dispersing agents. Evaluation of detergency. Advances in surface active agents.

Advanced technology of bleaching.

Chemistry, general properties, mechanism of optical brightening agent applicable to various fibres. Evaluation of bleaching, damages and defects caused by bleaching. Bleaching of man-made fibres, fabrics and their blends.

History and development of mercerization. Physical and chemical aspects of mercerization. Factors determining the efficiency of mercerization. Mercerizing machinery. Advances in textile auxiliaries used in scouring, bleaching and mercerization.

Chemistry, technology and mechanism of dyeing natural and man-made fibres and their blends.

Physical chemistry of dyeing.

Discontinuous, semi-continuous and continuous methods of application of dyes on natural fibres and study of the dyeing machinery involved.

Faults in dyeing and their remedies.

Computer colour matching etc. Evaluation of various

fastness of dyed textiles. Identification of dyes.

Group B

Advances in thickeners and assistances used in textile printing and their functions.

Printing procedures of different textiles and fabrics (including blends) with various classes of dyes pigment. Machines used for printing, drying, aging, steaming, etc.

Faults in printing and their remedies.

Transfer and foam printing. Screen preparation.

Computer-aided print design.

Chemistry and technology of finishing cotton, wool, silk, rayon and synthetic fabrics. Finishing chemical and auxiliaries—their functions and applications.

Permanent and semi-permanent finishes of different textiles, e.g., wash-n-wear, crease-resistant, anti-shrink, antistatic, water repellent finishes, mildew proofing, fireproofing, trubenizing, calendaring, crabbing, milling, felting and stentering.

Setting of synthetic fibres. Evaluation of finished fabrics.

Damages/ defects caused in finishing and their remedies.

Chemical processing, planning, including effluent treatments, water recycling, energy conservation, cost control.

Recommended Books

- o A Vaidya. Textile Auxiliaries and Finishing Chemicals. ATIRA, Ahmedabad.
- o M Lewin. Handbook of Fibre Science and Technology—Vol. 2. Functional Finishes Parts A & B. Marcel Dekkar Inc., New York.
- o R H Peters. Textile Chemistry—Parts 1 & 2. Elsevier Publishing Company, New York.
- o V A Sheno. Technology of Textile Processing—Vol. 6. Sevak Publication, Mumbai.
- o E R Trotman. Dyeing and Chemical Technology of Textile Fibres. B I Publications, New Delhi.
- o L W C Miles Textile Printing Society of Dyers & Colourists, England.
- o V A Sheno. Technology of Printing. Sevak Publication, Mumbai.
- o W Clerk. Introduction to Textile Printing. Newnes-Butterworths, London.

TX 432

GARMENT TECHNOLOGY

Group A

Apparel introduction, demands and the raw materials required for manufacturing of garments, scope and potentials for setting up of apparel industries. Requirements of manpower, machines, materials, etc and their testing.

Minor fabric construction—net, lace, bonded, etc.

Pattern making and dress designing. Pattern making theory,

principles of basic drafts, etc. Introduction to fullness in pattern making and its importance, etc. Different types of seams for different samples, etc. Drafting bodies at different age levels, etc., draping.

Group B

Introduction of various machines and equipment used in garment manufacturing and different types of cutting machines, etc.

Different types of sewing machines.

Detailed knowledge of different types of stitches. Tables used for cutting and stitching, etc. Dyeing and printing of garments and finishing of garments and washing, etc. Garment defects and their control.

Recommended Books

- o B Natalie. Dress Pattern Designing. Blackwell Science, London.
- o T Brackenbury. Knitted Clothing Technology. Blackwell Science, London.
- o P W Harrison (Ed.). Garment Dyeing. vol 19, no. 12, Blackwell Science, London.
- o H Carr and J Pomeroy. Fashion Design and Product Development. Blackwell Science, London.
- o G Cooklin. Introduction to Clothing Manufacture. Blackwell Science, London.

TX 433

CHEMISTRY AND TECHNOLOGY OF MAN-MADE FIBRES

Group A

Introduction to fibre-forming polymers: Types of polymerization reactions, polymerisation techniques. Determination of molecular weight. Importance of molecular weight and molecular weight distribution on the properties of fibrous polymers.

Chemical and physical characteristics of fibres. Chemical composition of more common man-made fibres.

Group B

Introduction to manufacturing processes for man-made fibres. A study of various systems of spinning, wet spinning, dry spinning and melt-spinning, production technology of important man-made fibres, viz., viscose rayons, cuprammonium rayons, acrylonitriles, polyolefins.

Recommended Books

- o H F Mark, SM Atlas and E Cornia. Man-made Fibres: Science & Technology. Interscience Publishing Co., New York.
- o R W Moncriff. Man-made Fibres. Newnes-Butterworths, London.
- o V B Gupta and V K Kothari. Manufactured Fibre Technology. Chapman & Hall, London.
- o A Vaidya. Synthetic Fibre Production. Prentice Hall of India (P) Ltd., New Delhi.

TX 434

ENERGY CONSERVATION, ENVIRONMENTAL AND POLLUTION CONTROL

Group A

Basic concepts of energy conservation in textile mills.

Energy conservation by process optimization and modification as well as by adoption of new technology vis-a-vis combined/ single stage process.

Low liquor and low add on techniques.

Farm processing.

Microprocessor-based control system, etc.

Water conservation in textile processing.

Group B

Environmental and pollution control. Introduction, ecological effects, causes/ effects of pollution on ecology. Water pollution and its control, classification of water pollutants, sources of water pollution. Effluent treatment, methods of plans, solid waste management.

Air pollution and its control, effects of air pollution, testing and monitoring air quality. Indoor Air Quality (IAQ), air pollution control devices.

Noise and its control. Basic chemistry involved in different steps of effluent treatment, important parameters related to air and water pollution and their permissible limits. Effects of biotechnology in textile finishing and enzyme finishing in textiles.

Recommended Books

- o M Lewin. Handbook of Fibre Science and Technology—Vol. 2. Functional Finishes-Parts A & B. Marcel Dekker Inc, New York.
- o L R Higgins. Maintenance Engineering Handbook. McGraw-Hill International.
- o H F Mark and E Cernia Atlas. Chemical After Treatment of Textiles. Interscience Publishers, New York.
- o P L Diwakar Rao. Pollution Control Handbook. Utility Publications Ltd., Secunderabad.
- o B Kotaiah and N Kumaraswamy. Environmental Engineering Laboratory Manual. Charotar Publishing House, Anand.
- o M L Gulrajani and Sanjay Gupta. Energy Conservation in Textile Net Processing. Omega Scientific Publishing Co., New Delhi.
- o P B Jhala, M M Vyas and K Subrahmanyam. Water and Effluents in Textile Mills. ATIRA, Ahmedabad.

TX 435

MILL ORGANISATION, PROCESS ECONOMICS AND QUALITY CONTROL

(See page 99, subject TX 415)

The Ideation

In the pioneering work of Leonardo da Vinci (1452-1519) on aviation, 'On the Flight of Birds', description and sketches of helicopters and parachutes as visualised by him were vividly given. On September 19, 1763, the Montgolfier brothers launched a balloon lifted by hot air. Sir George Cayley (1773-1857) was in a sense the inventor of the aeroplane because he defined the basic aerodynamic forces operating on a wing as early as in 1799.

The Dream Comes True

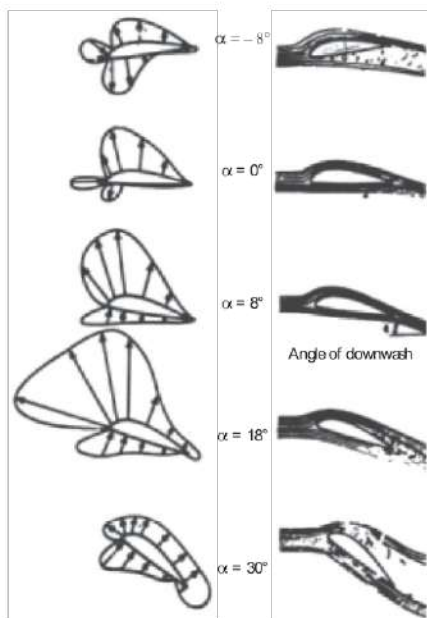
Otto Lilienthal began gliding experiments near Berlin in 1891. Hiram Maxim (1840-1916) opened a workshop in 1882 for experiments on mechanical flight. The Brazilian inventor, Alberto Santos-Dumont, experimented with automobile engines in airships and his ascent in 1898 was encouraging. However, the Wright Brothers of Ohio made their first successful flight in an engine-powered glider on December 17, 1903 leading to the development of aeroplanes. Italians made military use of air-borne machines in 1911. A Russian Officer Nesterov first 'looped the loop' and initiated aerobatics.

Lindberg's historic trans-Atlantic flight in 1927 proved the stamina and promise of aviation. In 1930, a gas turbine was developed with a centrifugal compressor to produce a high-velocity propulsion jet which would, in due course, replace the propelled aircraft.

Space Invasion

Congreve succeeded in perfecting a rocket for use in war. N I Kibalchitch visualised in 1892 a rocket with a solid propellant. However, R H Goddard developed the rocket in 1929 with liquid fuel which led to a positive advance in space science. Ballistic missiles then became major armaments with time.

With USSR launching an artificial satellite around the earth on October 4, 1957, a new era in space technology and communication began.

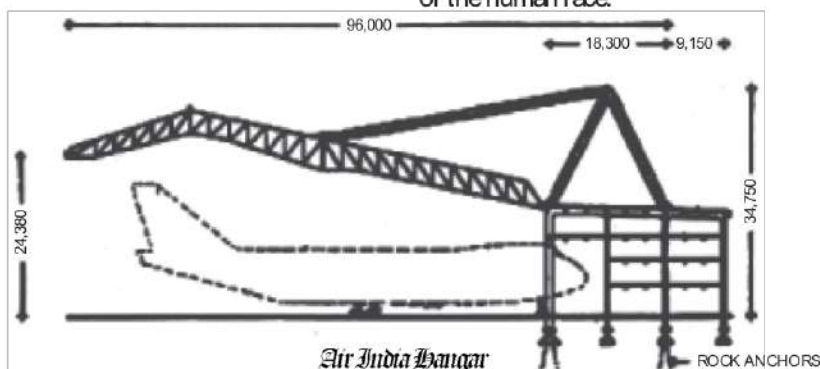


Distribution of pressure on a cambered wing at different angles of attack

India in the Race

Through the vision and drive of Dr Vikram Sarabhai and Dr. Homi JBhabha, the Indian space programme was initiated in 1962. Seven years later, the Indian Space Research Organisation (ISRO) was set up. Valuable research in the space sciences is based at the Physical Research Laboratory, the Space Physics Laboratory (SPL) at Vikram Sarabhai Space Centre (VSSC) and the Technical Physics Division (TPD) at ISRO Satellite Centre (ISAC), Bangalore. Alongside, the National Remote Sensing Agency (NRSA) has developed many modern sensing techniques for resource management. The Department of Space, created in 1972, is responsible for the establishment and operation of the INSAT space segment.

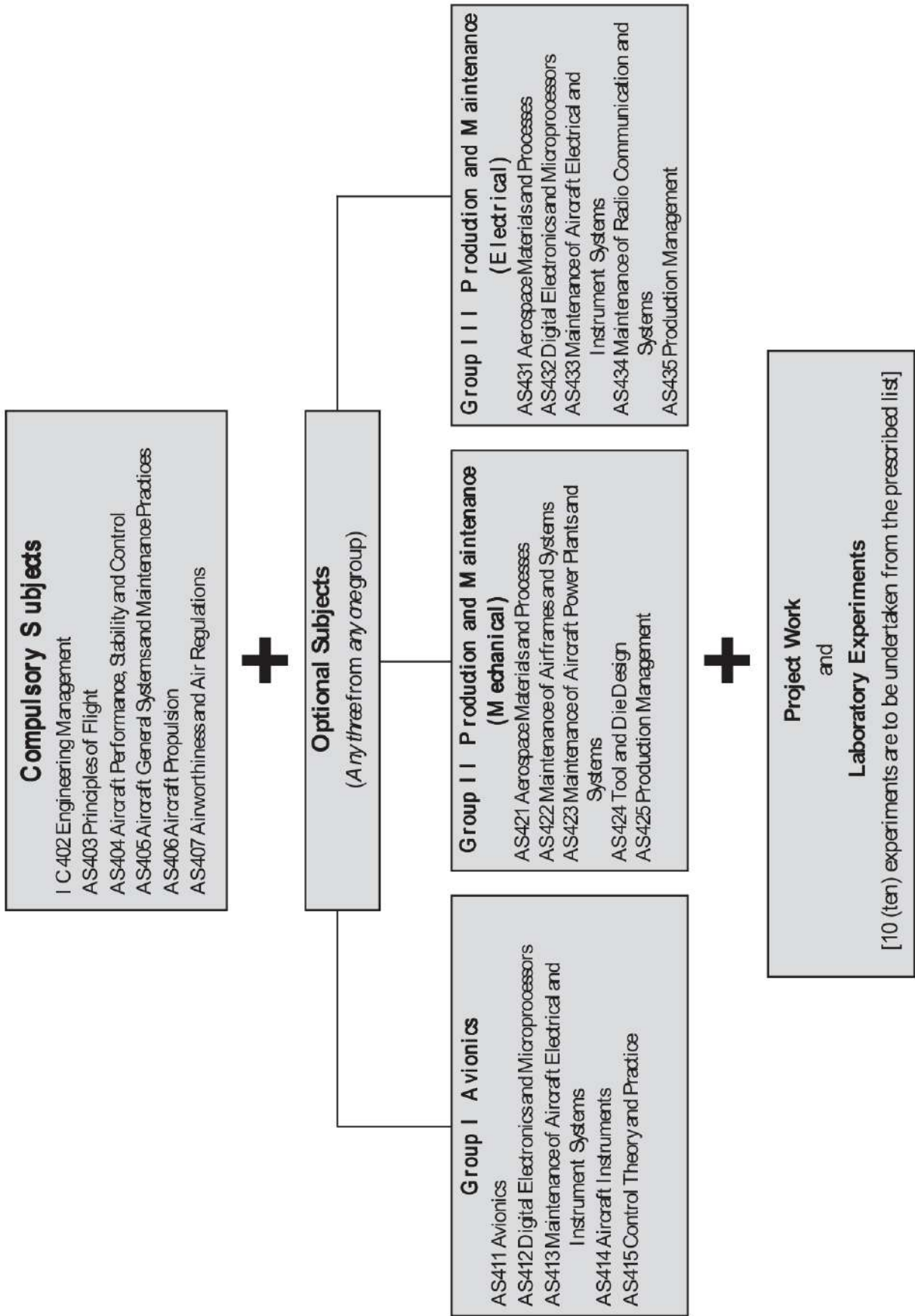
The first generation Indian National Satellite System (INSAT-1) was India's first step towards implementing operational space systems for specific peaceful national requirements. Starting with the first Indian Remote Sensing Satellite (IRS-1A), India's Space Programme has been successful in many ways and is still continuing to feed important scientific data for the benefit of the human race.



Aerospace engineering encompasses many branches of science and engineering to provide comprehensive perception for synthesis and integration of various aspects related to the design, development, field testing and commissioning of crafts to be used in space, for specific purposes.

Aerospace engineering requires vast engineering resources and technology integration in order to encompass commercial aviation, space exploration and air defence. It embraces a wide range of problem areas in aeronautical and allied engineering disciplines. The discipline is thus diversified with exposure to multidisciplinary topics.

AEROSPACE ENGINEERING



AEROSPACE ENGINEERING

IC 402

ENGINEERING MANAGEMENT

(See page 13, subject IC 402)

AS 403

PRINCIPLES OF FLIGHT

Group A

Different types of airplanes, different parts of an airplane and their nomenclatures. Classification based on mission, performance, shapes, aerodynamics, propulsion. Standard atmosphere and its properties.

Airfoils and wings, geometric parameters, fundamentals of incompressible and compressible flow over airfoils, pressure distribution. Aerodynamic characteristics, lift, drag, moment coefficients of airfoils.

Three-dimensional wings, wing planforms and their significance, aerodynamic coefficients. Wings for subsonic and supersonic flights. High lift devices and boundary layer control. Vortex dominated flow over wings. Drag characteristics, vortex drag, wave drag, estimation of drag of airfoils, wings and complete airplane.

Group B

Propellers, simple momentum theory, piston engines, jet engines, turbojet, turbofan and turbo prop engine; engine characteristics and performance.

Elements of aircraft performance, thrust/ power available and required curves, steady level flight, climb and glide, range and endurance, take off and landing performance.

Recommended Books

- .. B W McCormic. Aerodynamics, Aeronautics and Flight Mechanics. John Wiley International.
- .. A C Kermode. Mechanics of Flight. Himalayan Book Publishing Co., New Delhi.
- .. E L Houghton and A E Brock. Aerodynamics for Engineering Students. Edward Arnold.
- .. L J Clancy. Aerodynamics. Pitman & Sons, UK.

AS 404

AIRCRAFT PERFORMANCE, STABILITY AND CONTROL

Group A

Properties of atmosphere, standard atmosphere, airfoils and their properties, wing geometry, lift curve slope, high lift devices

Power/ thrust available/ required. Effect of altitude, forward speed on engine performance. Level flight performance, maximum, minimum and optimum speeds, maximum range and endurance.

Rate of climb and its variation with altitude. Absolute and service ceiling, take off and landing distance and effect of temperature and wind, one engine take off for multi engine civil aircraft. V-n diagram, gust maneuverability envelop.

Group B

Criteria for stability and controllability, longitudinal static stability, stick fixed and stick free stability, maneuver points, CG limits, stick forces, power effects with propeller and jet engines (lateral and directional stability and control, control response) (may be qualitatively).

Introductory dynamics stability, phugoid motion, short period motion, dutch roll, spiral and roll subsidence.

Recommended Books

- I C D Perkins and R E Hage. Aircraft Performance Stability and Control. John Wiley and Sons, New York.
- .. B Etkin and K L D Reid. Dynamics of Stability and Control Flight. John Wiley and Sons, New York.
- .. Babister. Aircraft Stability and Control. Pergamon Press, USA.
- .. A C Kermode. Mechanics of Flight. Himalayan Book Publishing Co., New Delhi.

AS 405

AIRCRAFT GENERAL SYSTEMS AND MAINTENANCE PRACTICES

Group A

General maintenance practices. Jacking, levelling, and mooring, refuelling and defuelling of aircraft, safety precautions, hydraulic and fluid systems, precautions against contamination. Identification of colour coding, symbols and other markings to identify the fluid systems.

Hydraulic system: Advantages and disadvantages, types of circuits, flow through pipes, pumps and motors, static performance, actuators, seals and backup rings, reservoirs, accumulators, contamination control filters, tubings and hose pipes, indicating and warning systems, emergency and redundant systems valves, flow dividers and integrators, cooling systems.

Servo-control system: Stability and response, electrohydraulic servo systems, position and force feedback, frequency response, principles of automatic control.

Pneumatic systems: Air-conditioning and pressurisation systems, deicing systems, heat loads, plumbing, cold air units, compact heat exchangers, valves, filters, air bottles, capsules and bellows, indication and warnings.

Group B

Oxygen systems. Gaseous and liquid oxygen systems, breathing masks, oxygen regulator, oxygen bottles, liquid to gas converters, emergency systems, pressure suits, indication and warnings. Landing gear systems. Types of landing gears and their design principles. Shock absorbing devices. Retracting mechanisms, wheels and brakes, antiskid systems, steering systems, indications and warnings.

Fuel systems: Types of fuels, their properties and testing, colour codes, fuel requirements, pumps, fuel transfer systems, fuel tanks, plumbing, valves, indications and warnings.

Lubrication systems: Types of lubrication systems, lubricants, cleaning agents.

Auxiliary power unit: Construction and operational features, fire protection systems, types of systems, flame proofing, fire walls, fire detection systems, fire extinguishing systems.

Seat safety systems: Ejection seats, survival packs, parachutes, Pilot's personal equipment, life rafts, doors, windows and emergency exits, seat belts. System testing. Ground handling equipment.

Recommended Books

- .. H G Convey. Aircraft Hydraulics. Chapman and Wills Ltd., UK.
- .. W Green. Aircraft Hydraulic Systems. John Wiley and Sons, New York.
- .. E A D Saunders. Heat Exchangers. John Wiley and Sons, New York.
- .. H G Convey. Landing Gear Design. Chapman and Wills Ltd., UK.

AS 406

AIRCRAFT PROPULSION

Group A

IC engine propulsion: Introduction. Preliminary nomenclature, four-stroke cycle, engine types, functions of parts and their materials, fundamental quantities, gas laws, forms of energy, non-flow process, flow process.

Combustion: Theories of combustion highlighting fuel characteristics—flash point, fire point, etc., flames diffusion, premixed, flame stability, chemical equilibrium and dissociation, combustion equations, properties of air, combustible elements in fuels, combustion with air, heat of combustion.

Cycles and process: The Otto cycle, the diesel cycle, the dual cycle, comparison of air standard cycles, the air engine cycle calculation, exhaust process of the radial engine.

Engine friction and lubrication: Total engine friction, piston friction, bearing and auxiliary friction, pumping friction, lubrication, important properties of engine lubricants, engine

oil additives, dilution of oil by the fuel, lubrication systems (splash, semi-pressure, pressure and dry sump systems), typical example of an aircraft engine lubrication system, engine test to estimate mechanical friction and pumping friction.

Combustion and spark ignition engine: Normal combustion in spark ignition (SI) engine, auto-ignition of end charge, knock and detonation, pre-ignition and postignition. Effect of engine operating variables on knock rating of spark ignition fuels, anti-knock agents, knock and SI engine performance.

Carburation: Fuel-air ratio requirements of the engine under different load conditions, fuel carburation system, venturi tube, fuel flow, fuel-air ratio, performance of a simple carburetor, elements of complete carburetor, effect of altitude, typical aircraft carburetor arrangement, injection carburation, continuous and timed injection, working principles with typical examples.

Supercharging: Types of superchargers, supercharger efficiencies, power to drive superchargers, constructional details of centrifugal supercharger, purpose and performance of supercharged aircraft engine, typical examples of gear driven superchargers and exhaust turbosuperchargers, comparison of gear driven and turbo superchargers.

Ignition: Ignition timing and performance, effect of ignition timing on output, factors affecting spark advance, ignition timing and cylinder temperature, location of spark plug, battery ignition system, magneto ignition, aircraft engine plugs, altitude effects on ignition apparatus. Types of IC engines, thermodynamic aspects. Application and suitability of IC engines for aircraft propulsion.

Cycle analysis: Ideal cycle, modification to ideal cycles, polytropic efficiency, design point performance calculations, comparative performance of practical cycles.

Group B

Gas turbine cycles and aircraft propulsion. Criteria of performance, intake and propelling nozzle efficiencies, simple turbojet, turbo fan and turbo prop engine.

Gas turbine constructional features. Inlet ducts, compressors, combustion chambers, turbines and exhaust systems.

Exhaust nozzles: Types of nozzles, convergent, convergent-divergent, ejector nozzles, thrust equation, nozzle efficiency, performance characteristics. Principles of thrust augmentation, various methods, reheat and water methanol injection, configuration of systems, components of the system.

Engine testing: Types of test cells, requirements of instrumentation in a test cell, performance testing and analysis, ground operating procedures, starting and stopping procedures, engine operation and checks, engineering.

Gas turbine materials: Properties and types of aluminium alloys, steel alloys, nickel base alloys, cobalt base alloys, requirements of materials for compressors, combustion chamber and turbines, single crystal and directionally solidified

blades, use of composite materials.

Gas turbine systems and accessories. Fuels system components, fuel and typical fuel systems, lubricating oils and lubricating systems, secondary air system, ignition system, starting systems, hydraulic systems, control systems, typical aircraft accessory gear boxes.

Turbomachinery: Types of compressors, comparison between centrifugal and axial flow compressor, adiabatic compression and efficiency of compressor, cooled compressor and isothermal efficiency, polytropic efficiency and overall efficiency. Working of a centrifugal compressor, velocity triangles at impeller eye and tip, effect of vaneless space and function of a diffuser, worked examples. Characteristics of centrifugal compressors, surging. Real cycle analysis for turbo fan engines.

Axial flow compressors, allowable temperature and pressure rise per stage, blade nomenclature, pressure loss coefficient, lift and drag losses in blade passages, stall and surge, simple design examples. Types of losses in turbine blades, introduction to cooled blades.

Combustion chamber: Types of combustion chambers, intake design and desirable features of combustion chambers, process of combustion.

Recommended Books

- .. A R Rogowski. Elements of Internal Combustion Engines. Tata McGraw Hill Publishing Co. Ltd., New Delhi.
- .. D R Pye. The Internal Combustion Engine: Vols I and II. Oxford University Press, New Delhi.
- .. J L Karebrook. Aircraft Engines and Gas Turbine. MIT Press, USA.
- .. J D Mattingly. Elements of Gas Turbine Propulsion. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- .. Mc Mohan. Aircraft Propulsion. Pitman and Sons, UK.

AS 407

AIRWORTHINESS AND AIR REGULATIONS

Group A

Aircraft manual, civil aviation requirements, airworthiness requirements for civil and military aircrafts, CAA, FAA, JAR, ICAO military standards and specifications.

Privileges and responsibilities of various categories of AME license, knowledge of mandatory documents like certificate of registration, certificate of airworthiness—condition of issue and validity. Knowledge of log book, journey log book, technical log book, etc. Procedure for development and test flights and certification, certificate of flight release, certificate of maintenance, approved certificates.

Group B

Flight manual, aircraft schedules, registration procedure, certification, identification and marking of aircraft, modifications,

concessions, airworthiness directives, service bulletins.

Crew training and their licenses, approved materials, identification of approved materials.

Bonded and quarantine stores, storage of various aeronautical products like rubber goods, various fluids.

Accident investigations procedures, circumstances under which C of A is suspended, ICAO and IATA regulations. Chicago and Warsaw conventions

Aeronautical information circulars.

Airworthiness advisory circulars.

Aircraft maintenance engineers circulars.

Recommended Books

- .. The Indian Aircraft Act and the Rules, DGCA.
- .. Civil Aircraft Inspection Procedure (CAP & 59)—Part II; Aircraft Part I : Basic.
- .. Manual of Civil Aviation, DGCA.
- .. Civil Aviation Requirements (Part II-Airworthiness) DGCA.

AS 411

AVIONICS

Group A

Radio wave propagation methods, modulation, frequency control, antenna fundamentals, principles of radiation, power patterns, radiation intensity and directivity, gear, field patterns, concept of electric pole, directional properties of antennas, antennas for LF, MF and HF, antennas for MW frequencies (qualitative treatment only).

Communication systems. HF, VHF, UHF, microwaves, signal and noise, coded forms, distortion, modulation, demodulation, data links, telemetry.

EMI, EMC, pulse modulation, coding and decoding circuits.

Amplitude and phase distortion. Television waveforms, scanning. Circuits for transmitters and receivers. Data conversion, analog multiplexers, A/D and D/A conversion.

Data storage, opto-electronics, light-emitting diodes, CRT displays, semiconductor and solid state lasers, optical fibres, communication using fibres.

Group B

Satellite communication, spread spectrum technology, satellite transponders, earth terminals.

Microwave engineering, active devices, lighthouse tubes, klystrons, magnetrons, TWTs wave oscillators, microwave transistors, point contact diodes, tunnel diodes, GUNN diodes, passive microwave devices ferrites, ferrite devices, cavities. Radar systems, range, CW and frequency modulated radars. Doppler radar, pulse radar, tracking radar, synthetic aperture radar, radar signal processing, weather radar.

Introduction to navigation systems, radio navigation, TACAN, ADF, VORDME, OMEGA, GPS, Doppler, LORAN-C, internal navigation, strap down systems, ILS, MLS

Avionics system design, development and integration, simulation techniques, system architecture, databases, MIL-STD-1553B, ARINC-429.

Need for avionics in civil and military aircraft, integrated avionic and weapon system concept, typical avionics sub-systems and technologies.

Recommended Books

- .. B P Lathi. Communication Systems. John Wiley and Sons, New York.
- .. M Kayton and W R Fried. Avionic Navigation Systems. John Wiley and Sons, New York.
- .. R E Collin. Foundation of Microwave Engineering. McGraw-Hill International.
- .. A K Maini. All-in-One Electronics Simplified. (khannabooks.com). Khanna Books, Delhi.
- .. N S Nagaraja. Elements of Electronic Navigation. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

AS 412

DIGITAL ELECTRONICS AND MICROPROCESSORS

Group A

The CPU, CPU register, ALU control unit, status, flags, introduction, execution, instruction, timing diagrams, instruction cycles, microprogramming and the control unit, chip slice units.

Logic beyond the CPU. Interfacing programs and data. Memory program I/O, interrupt, error detection, various protocols, synchronous serial data transfer, programmable control/timers, real time clock, logic distribution among microcomputer devices. Programming microcomputer, review of programming language, source program, object program, assembly language, memory addressing, stack indirect addressing, indexed addressing, base relative addressing, memory segmentation.

Group B

Introduction to sets. CPU architecture. A description of instructions, advanced microprocessor instruction set concepts. Boolean algebra, postulates and theorems, standard forms, formulation of switching functions, simplification of Boolean expressions. Basic building block, realization of switching function using NAND and NOR gates. Flip flops, counters and shift registers.

Analysis of digital logic families; TTL, MOS, CMOS inverters; interfacing between logic families; various functions and their implementation; bistable circuits R-S, J-K, D and PLA; design of synchronous sequential circuits and their applications; serial and parallel ports.

Recommended Books

- .. A P Gautam. Advance Microprocessors Khanna Book Publishing Co. Ltd., New Delhi.
- .. Rishabh Anand. Digital Electronics (khannabooks.com) Khanna Publishing, New Delhi.
- .. R S Gaonkar. Microprocessor Architecture, Programming and Applications. New Age International (P) Ltd., New Delhi.

AS 413

MAINTENANCE OF AIRCRAFT ELECTRICAL AND INSTRUMENT SYSTEMS

Group A

Detailed knowledge of series and parallel resonance of a.c. circuits and their use, calculation of resonant frequency of a circuit from a given information, effect of change in the frequency on the impedance, current and phase angle.

Detailed knowledge of the composition, performance (stability and tolerance) and limitations of fixed resistors (carbon composition, carbon film, wire mould and metallic film) and description of various types of variable resistors (wire resistors and varistors).

Knowledge of resistor colour codes, value and tolerance, and the system of preferred values and wattage ratings. Detailed knowledge of the construction, principles of operation, application and colour coding of various types of capacitors. Detailed knowledge of circuit controlling and current protection devices.

Aircraft batteries. Construction and principle of operation of lead acid-nickel-cadmium and silver zinc batteries. Charging of batteries, common defects and rectification.

Generators and motors: Construction, principle of operation and characteristics of d.c. and a.c. generators and motors. Voltage regulators, functional tests and speed control.

Servo-mechanism and amplifiers: Construction and principle of operation of auto-transformers, single and three-phase transformers. Saturable reactors and magnetic amplifiers. Servo motors and rate generators.

Test equipment: Knowledge of construction and principle of operation for aircraft test equipment. Bonding and screening. Standards for insulation and bonding, aircraft wiring system.

Group B

Knowledge of the atmosphere. Knowledge of basic principle of thermionics and properties of semiconductor materials. Knowledge of symbols, truth tables and equivalent circuits for logic gates. Knowledge of the terms used, basic operation and interfacing of major components of computer. Knowledge of the types and operation of displays (LED, liquid crystal, etc). Knowledge of CRTs and its application.

Knowledge of functions performed and overall operation of a microprocessor. Knowledge of handling of microelectronic circuit devices [electrostatic sensitive devices (ESD)]. General understanding of the terms relating to theory of flight—longitudinal axis, lateral axis and vertical axis, yawing, rolling, pitching, azimuth heading, course, sideslip, skidding, coordinated turn, stability, angle of attack, chord, stall, lift drag, thrust.

General knowledge of the purpose and action of primary control surfaces, trim tabs and wing flaps. Knowledge of the principle of operation, construction and characteristics of pressure-sensitive and temperature-sensitive elements. Knowledge of the principle of operation, constructional features and characteristics of gyroscopes.

Reliability. Elements of probability, definition of reliability, statistical analysis life-time data, determination of reliability. Introduction to system reliability, maintainability and availability of repairable systems. Fault-tree analysis.

Recommended Books

- .. E W Golding and F C Widdies. Electrical Measurements and Measuring Instruments. Pitman & Sons, UK.
- .. E F Warner. Aircraft Instruments Maintenance. McGraw Hill International.
- .. A K Maini. All-in-One Electronics Simplified. Khannabooks.com.

AS 414

AIRCRAFT INSTRUMENTS

Group A

Units and standards, theory of measurement, functional analysis of measurement, errors and error estimation. Measurement of voltage and current in d.c. and a.c., VTVM digital voltmeter, measurement of power, phase angle, power factor. Extension of range by instrument transformers, fluxmeter, measurement of frequency, heterodyne technique and digital frequency counters, signal generators.

Measurement of circuit elements, LCR direct and bridge methods. Waveform analysis, cathode ray oscilloscopes, measurement of harmonic and intermodulation distortion, distortion analyser, spectrum analyser.

Group B

Generalised configurations and performance characteristics of instruments, motion requirement, relative displacement and velocity. Translational and seismic displacement, velocity and acceleration measurements, torque measurement and rotating shaft, pressure and flow measurements. Fuel gauging systems, temperature based on expansion, electric resistance and radiation methods, problems involved in temperature measurements, compensation techniques, magnetic compasses.

Requirements for airborne equipment, sensors for the

measurement of position, altitude, air speed, acceleration, temperature, fuel flow and quantity. Instrument displays, panels and cockpit layout, flight instruments, gyroscopic instruments, power plant instruments, navigation instruments, miscellaneous instruments, RLGs.

Moving map displays, multifunction displays, headup displays, glass cockpit. Cockpit lighting, panels—integral, glow panels.

Recommended Books

- .. E H J Pallet. Aircraft Instruments—Principles and Applications. Pitman and Sons, UK.
- .. E W Golding and F C Widdies. Electrical Measurements and Measuring Instruments. Pitman and Sons, UK.
- .. C A Williams. Aircraft Instruments and Control System. Odham Press, USA.

AS 415

CONTROL THEORY AND PRACTICE

Group A

Introduction to Laplace transform, Fourier transforms, definition of feedback terms, symbols to represent feedback control variables, characteristics of basic feedback loop.

Introduction to dynamics of stable and unstable vehicles. Definition of aerodynamic coefficients, force and moment equations, definition of relaxed static stability, CCV concept in modern flight control system.

Models of transfer functions and systems. Its variables and equations, modeling of passive electrical components and systems, static and dynamic variables, modeling of d.c. motors and servo systems, transducer, sensors and actuators, transport delay.

Frequency response analysis. Open loop and closed loop poles and zeros; Nyquist diagram; Nyquist stability criterion; and stability margins, illustration of phase margin and gain margins.

The BODE magnitude plot. Studies of BODE phase plot, stability margins on the BODE plot, time delay effects. The root locus method. The locus equations, properties, and sketching rules, loci for systems.

Time response. Steady state error, transient response to a input, performance measures.

Group B

System design: (a) Signal conversion and processing—digital signals and coding, data conversions and quantization sample and hold devices, digital to analog conversion, analog to digital conversion, the sampling theorem, reconstruction of sampled signals; (b) Compensation networks, system effects of offset and noise; (c) Servo components—synchros, sensors, actuators,

computers; (d) Electronic design aspects—rating, time delays, reasonable values, etc., proportion controller, proportional integral controller, proportional integral differential controller (PID).

The Z-Transform. Definition of Z transform; evaluation of Z transform; mapping between s-plane and z-plane; The inverse Z transform, theorems of Z transform.

The state variable technique. State equations and state transition equations of continuous data system; state transition equations of digital systems; relation between state equation and transfer function; characteristic equation, eigen values and eigen vectors, diagonalisation of A matrix, methods of computing the state transition matrix.

Stability of digital control system, time-domain analysis, frequency domain analysis.

Recommended Books

- .. D B Miron. Design of Feedback Systems. Harcourt Brace Jovanovic Publications, New York.
- .. K Ogata. Modern Control Engineering. Prentice Hall of India (P) Ltd., New Delhi.
- .. A Ambikapathy. Control Engineering. Khanna Book Publishing, Delhi..

AS 421

AEROSPACE MATERIALS AND PROCESSES

Group A

Structure of material and their characteristics, nature of metals, ceramics, polymers and composites, spectrum of material properties—chemical, physical, mechanical and dimensional.

Mechanical properties. Isotropy, orthotropy, anisotropy, true stress-strain and engineering stress-strain diagrams, tensile test, hardness test, impact test, ductility, toughness and hardness of material.

Concept of fatigue and creep. Endurance limit, creep strength, stress rupture. Testing of aerospace material, hardness Brinell, Rockwell, Vickers, Impact-charpy, izod, fatigue, torsion.

Types of mechanical tests. Tension, compression, shear, bending, crushing, hydrostatic, design of tests.

Non-destructive testing. Radiographic methods, electromagnetic methods, magnetic particle method, dye penetrant method, ultrasonic testing, techniques, acoustic emission technique, eddy current.

Group B

Broad classification of aerospace materials; ferrous and non-ferrous materials; aluminum and its alloys; typical application, classification, properties, designations of alloys, heat treatment, surface treatment, magnesium and its alloys; typical application, properties, designation, steels; classification, effects of alloying

element in steels, nimonic alloys. Applications, titanium and its alloys, polymers, classifications, additives to polymers, mechanical properties, application.

Furnishing materials; Wood, plywood, dope, glue rubber. Methods of testing and storage, points surface finish.

Composite materials, metal matrix, polymer-matrix, particulate composites, fibre reinforced composites, various types of reinforcements, application, manufacturing of composites, corrosion; detection and prevention, protective finishes, short fibre composites, random fibre composites.

Recommended Books

- .. M S Ray. The Technology and Application of Engineering Materials. Prentice Hall of India (P) Ltd., New Delhi.
- .. K G Budinski and M K Budinski. Engineering Materials: Properties and Selection. Prentice-Hall International.
- .. T J Titterton. Aircraft Materials. English Book Store, New Delhi.
- .. R M Jones. Introduction to Composite Materials. Technomic Publications, USA.

AS 422

MAINTENANCE OF AIRFRAMES AND SYSTEMS

Group A

Aerodynamics: Subsonic airflow, characteristics of airfoils, forces acting on the aircraft, aircraft stability and control, effect of altitude, weight and power on the performance of aircraft.

Aircraft structures: Various types of structures in aircraft construction, tubular, braced monocoque, semi-monocoque, etc, longerons, stringers, formers, bulkhead, spars and ribs, honeycomb construction.

Airplane controls, ailerons, elevators, stabiliser, rudder, trimming and control tabs, leading and trailing edge flaps, tailplane and fins. Knowledge of structure and structural components fabricated from metal, glass fibre, vinyl, perplek, composites. Finishing materials, paints, surface finishes and associated materials.

Aircraft system: Flying controls including power operated controls, hydraulics, pneumatics, landing gear of various types, shock struts, nose wheel steering, ice and rain protection, fire detection warning and extinguishing, oxygen, air-conditioning and pressurisation systems, wheels, tyres, brakes, anti-skid system. Windows, doors and emergency exits. Reliability and redundancy of systems design.

Group B

Inspection: Basic principles of inspection, inspection gauges and tools, standard inspection techniques and procedures. Go/no go gauges, gauge calibration and maintenance, limits and tolerances. NDT techniques.

Major and minor damage, damage tolerance. Corrosion and corrosion prevention.

Major and minor defects. Defect reporting, rectification and investigation. Rigging of aircraft, symmetry checks.

Balancing of control surfaces, periodical inspections, heavy landing, overweight landing checks, abnormal flight loads, aircraft weighing, weight schedule, calculation of C and G.

Reliability. Elements of probability, definition of reliability, statistical analysis of lifetime data, determination of reliability. Introduction to system reliability, maintainability and availability of repairable systems, fault tree analysis.

Recommended Books

- .. Aircraft Manual, DGCA.
- .. Civil Airworthiness Requirements (CAA), UK.
- .. Civil Aircraft Inspection Procedures (CAP 459)—Part II Aircraft. Himalaya Publishing Co., Mumbai.
- .. L S Srinath. Reliability Engineering. Affiliated East-West Press (P) Ltd., New Delhi.

AS 423

MAINTENANCE OF AIRCRAFT POWER PLANTS AND SYSTEMS

Group A

Piston engines. Knowledge of thermodynamics laws related to IC engines. Two— and four—stroke engines. Efficiency factors affecting engine performance.

Knowledge of the function and construction of various parts and accessories of the engine, including induction, exhaust and cooling system, engine mounting. Engine fire detection and protection systems.

Propellers. Knowledge of purpose and functioning of parts of constant speed, variable pitch and feathering propellers and associated control system components.

Engine fuel and oil system. Construction features of carburetors, engine fuel and oil systems. Characteristics of aviation fuel and oil, common sources of contamination, methods of checking contamination.

Ignition and starting systems. Magnetos and ignition system components, various types of engine starters.

Group B

Engine instruments: Principles of operation. Supercharges—constructional features and principles of operation and function of various types of supercharges and its related component.

Gas turbine: Principle of operation, general constructional details and function of various types of gas turbine engines such as turbojet, turbo fan and by-pass engine. Theory of gas turbine engines, advantages and disadvantages of each type. Induction, exhaust and cooling systems, anticing of engine, engine mounting, thrust augmentation. Compressor surge and

stall bleed control system.

Principles of operation, general constructional details and functions of fuel and oil systems, ignition and starting systems and their components. Engine controls of various types, including Full Authority Digital Electronic Control Engine instruments. Power augmentation devices, thrust reversers and auxiliary power units.

Engine maintenance. Piston/gas turbines—periodical servicing procedures, engine installation checks, control rigging, ground running checks, priming, bleeding and performance checks. Engine on condition maintenance. Trouble-shooting and rectification. Inspection after shock landing, crack detection. Procedure for long and short term storage of engine and accessories, engine preservation and depreservation.

Recommended Books

- .. E Mangham and A Peace. Jet Engine Manual. Newnes, London.
- .. A W Judge. Carburetors and Fuel Injection System. Chapman & Hall, London.
- .. P W Gill, J H Smith and E J Ziurys. Fundamentals of Internal Combustion Engines. United States Naval Institute, Maryland.
- .. A W Judge. Gas Turbine for Aircraft. Chapman & Hall, London.
- .. V Cassamassa and R D Bent. Jet Aircraft Power Systems. McGraw-Hill International.

AS 424

TOOL AND DIE DESIGN

(See page 68, subject MC 433)

AS 425

PRODUCTION MANAGEMENT

(See page 69, subject MC 435)

AS 431

AEROSPACE MATERIALS AND PROCESSES

(See page 110, subject AS 421)

AS 432

DIGITAL ELECTRONICS AND MICROPROCESSORS

(See page 108, subject AS 412)

AS 433

MAINTENANCE OF AIRCRAFT ELECTRICAL AND INSTRUMENT SYSTEMS

(See page 108, subject AS 413)

MAINTENANCE OF RADIO COMMUNICATION AND SYSTEMS

Group A

Detailed knowledge of thermionics emission, constructional features, application, limitation and functioning of thermionic valves, materials, application and properties of semiconductors, construction, symbols, doping process, operation, application and characteristics of P-N-P and N-P-N transistors. Comparison with vacuum tubes; construction, symbols, operation and anode characteristics of vacuum and gas-filled tubes, knowledge of their construction and application. Construction and principles of auto-transformers, single- and three-phase transformers, construction and principles of operation of saturable reactors and magnetic amplifiers, bias, phase sensitive half-wave and inputs and outputs, polarity sensitive inputs and outputs, pushpull outputs and effects of stage gains and cascading on time response. Use and theory of oscillators and multivibrators. Knowledge of symbols, truth tables and equivalent circuits for logic gates, operation and application of flip flop logic, basic operation, interfacing of major components of a computer.

Use and types of Medium Scale Integration (MSI) devices, types and operation of displays (LED) liquid crystal, etc. Function of CRTs and its application in aviation functions performed and overall operation of a microprocessor handling of microelectronic circuit devices [(electrostatic sensitive devices (ESD))]. Electrical power distribution systems, operation and construction of static inverters, rotary inverters and transformer rectifier units.

Group B

Modulation and demodulation, amplitude, frequency and phase modulation, AM and FM receivers, transmitter, superhetrodyne principle, balanced modulator, radio frequency transmission lines, coaxial cables, current and voltage distribution, impedance of lines, standing waves, standing wave ratio, matching, tuning stubs, waveguides, attenuation in waveguides, resonant cavities, interference caused by electrical and ignition system to radio apparatus, methods of minimizing or suppressing such interference, bonding and screening. Identification, use, propagation characteristics and identification of band spectrum, construction and identification of various

types of antennas, voltage and current distribution along antenna of various lengths, characteristics of ground planes. Very high frequency (VHF) and high frequency (HF) airborne communication, frequency bands allocation, the methods of propagation and the ranges expected both day and night, calculation of approximate ranges of communication (line of sight) with given data. Performance levels expected and specifications of typical airborne HF and VHF communication systems, principle of operation, installation practices and procedures, functioning of the operating controls and indications and maintenance of typical HF and VHF communication transceivers. Theory of operation, performance level and specifications of an audio integration system. Working principles and testing of lead acid and nickel cadmium batteries, purpose, chemical combination, flux used, tinning for soldering. Bonding and screening.

Knowledge of terms used, principle, operation, characteristics. Automatic Direction Finder (ADF) systems. Very high frequency (VHF) Omni Directional Range System Instrument, landing systems, weather radar systems, microwave devices, air traffic control (ATC) transponder system, very low frequency (VLF) navigation systems (nH), omega navigation system, radio altimeter systems, cockpit voice recorder, distance measuring equipment, doppler navigation system, microwave landing system, ground proximity working systems, emergency locator transmitters, principle of satellite communication and its application to aircraft.

Recommended Books

- .. JH H Grover. Aircraft Communication System. Heywood and Company Ltd., London.
- .. W F Lovering Longman. Radio Communication. Green and Co., London.
- .. RF Hansford. Radio Aids to Civil Aviation. Heywood and Co. Ltd., London.
- .. D Reddy and J Cooler. Electronic Communication. Prentice Hall of India (P) Ltd., New Delhi.

PRODUCTION MANAGEMENT

(See page 69, subject MC 435)

AGRICULTURAL ENGINEERING

Earliest Engineering to Civilize the World

Agriculture is the art and science of crop and livestock production. In its broadest sense, agriculture comprises the entire range of technologies associated with the production of useful products from plants and animals, including soil cultivation, crop and livestock management, and the activities of processing and marketing. The term agribusiness has been coined to include all the technologies that mesh in the total inputs and outputs of the farming sector. In this light, agriculture encompasses the whole range of economic activities involved in manufacturing and distributing the industrial inputs used in farming; the farm production of crops, animals and animal products; the processing of these materials into finished products; and the provision of products at a time and place demanded by consumers.

Technology Pushes

Many different factors like climate, soil, water availability and topography vary widely throughout the world and influence the kind of agriculture practised in a particular area. This variation brings about a wide range in agricultural production enterprises. Certain areas tend toward a specialised agriculture, whereas other areas engage in a more diversified agriculture. As new technology is introduced and adopted, environmental factors become less important in influencing agricultural production patterns. Continued growth in the world's population makes critical the sustaining ability of agriculture to provide needed food and fibre.

Mechanization of the modern farmstead has become a reality, and agricultural engineers have been largely responsible. Automation is now the goal in front of agricultural engineers. The different dimensions of agricultural

engineering involve the management and beneficial use of soil and water resources, control of soil erosion and soil moisture for crop production, prevention of food and water pollution.

Post-harvest processing such as drying of grains and forages, washing, grading and storage of fruits and vegetables, including controlled atmosphere systems, and ginning of cotton are typical on-the-farm applications of agricultural engineering.

Hydraulically powered mechanized systems of food and fibre production extend from initial tillage of the soil through planting, cultural practices during the growing season, protection from pests, harvesting, conditioning, livestock feeding, and delivery of the produce for processing.

The most sophisticated technology is used to increase the precision needed in modern agriculture. Lasers are used for laying out irrigation systems; microprocessors are used for sensing and controlling intricate operations such as controlling feed mixtures for dairy cows and grading fruits and vegetables; electronic devices are used in the automation of many harvesters. The use of aircraft has revolutionized many farming operations. The crop is sown in flooded fields, and fertilizers, pesticides and herbicides are applied from the air.

The Indian Perspective

Economic regeneration through the successive Five-Year Plans has made agriculture a source of national pride. This sector today provides livelihood to about 60% of the labour force. It supplies the bulk of wage goods required by the non-agricultural sector and raw material for a large section of industry.

In terms of gross fertiliser consumption, India ranks fourth in the world, after USA, USSR and China. The country has the largest area in the world under pulse crops. In the field of cotton, India is the pioneer to evolve a cotton hybrid. The country has made major breakthroughs in prawn seed production

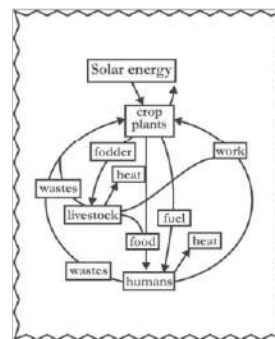
and pearl culture technology. High yielding varieties of grains are widely used for increasing the agricultural production in the country.

The Indian Council of Agricultural Research (ICAR), set up in 1929, is the apex body for formulating plans and coordinating research and field work in agriculture, animal husbandry and fisheries through the medium of extension agencies under the Central and State Governments. It has a well-knit network of many universities, institutes, research centres and other bodies to provide undergraduate and postgraduate education.

Agricultural Engineering – Its Role

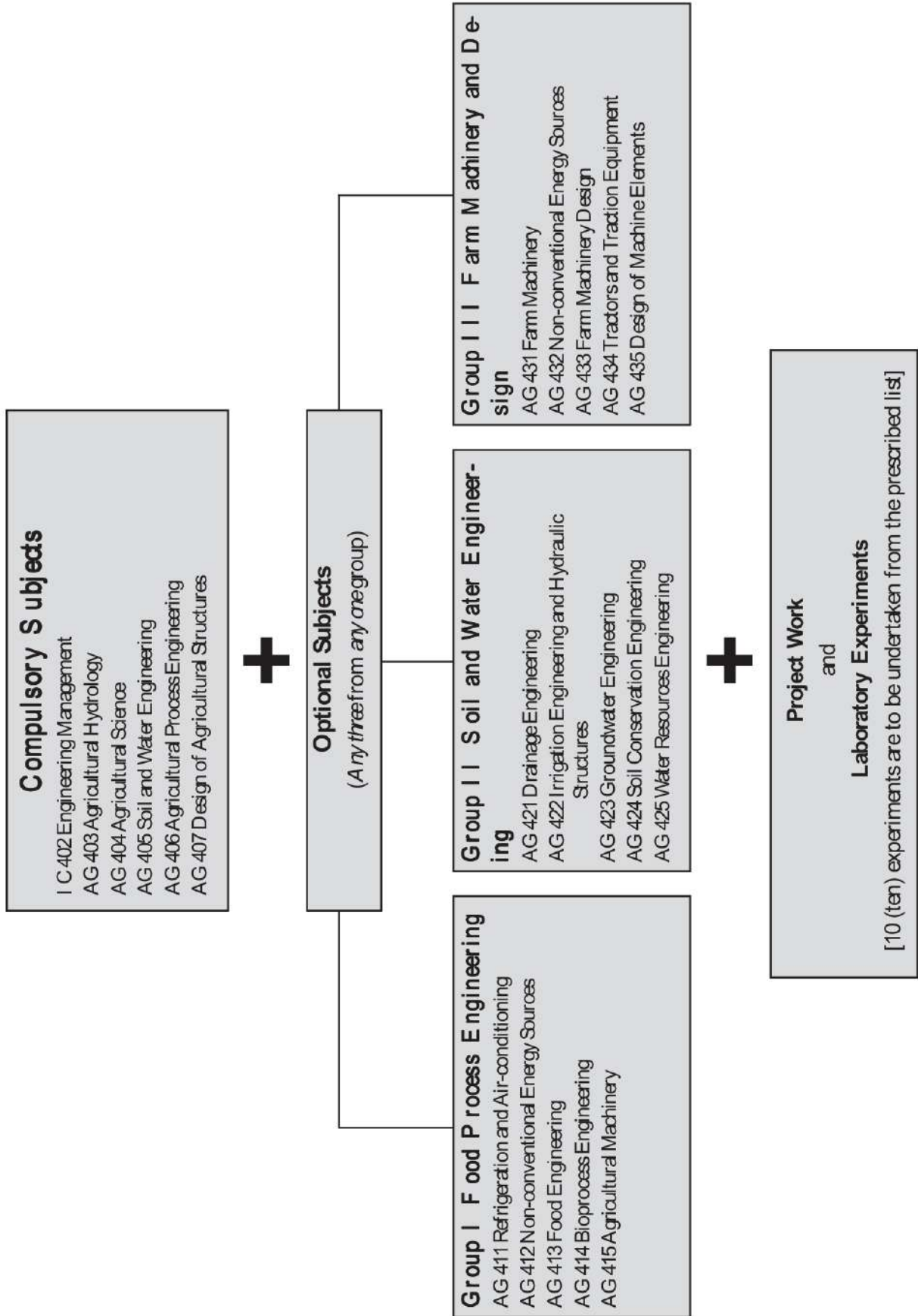
It is the engineering discipline directly concerned with developing means for providing food and fibre. Nearly all problems that agricultural engineers deal with involve biological materials, systems, and processes. Application of physical and engineering sciences to the solution of such problems is the distinguishing feature of agricultural engineering.

An emerging area of great importance for the future is the modification and control of the soil, water and air environment of plants. As greater production is demanded from an ever-decreasing available land area, increasing attention is being given to modify the natural environment to produce conditions nearly ideal for plant growth. Controlled environment for animal production within confined housing systems is another area of activity that interests agricultural engineers today.



Ago-ecosystem

AGRICULTURAL ENGINEERING



IC 402

ENGINEERING MANAGEMENT

(See page 13, subject IC 402)

AG 403

AGRICULTURAL HYDROLOGY

Group A

Hydrology cycle. Hydrologic budget. Inventory of the India's water. Space-time scales in hydrology.

Types of watershed—classification by size and by land use. Quantitative characteristics of the drainage basin basin order and channel order, basin area, basin shape, basin slope, centroid, basin length, drainage density.

Atmospheric water vapour and its indices. Air circulation. Weather systems and fronts. Mechanism of precipitation. Types of precipitation.

Measurement of rainfall. Design of rain gauge network. Consistency of rainfall records, filling in missing records, extension of a point-rainfall record. Mean areal precipitation. Graphical presentation of rainfall data.

Infiltration process. Zones of subsurface water. Factors affecting infiltration. Measurement of infiltration. Empirical and analytical models of infiltration. Soil moisture and soil moisture losses.

Baseflow. Baseflow contribution to streamflow. Baseflow recession curve. Baseflow and physiographic characteristics.

Evaporation process—factors affecting evaporation, measurement, determination of evaporation from water surfaces. Transpiration—measurement of transpiration. Evapotranspiration—determination of transpiration.

Group B

Streamflow measurement—measurements of stage, velocity and discharge. Stage-discharge relationship. Extension of rating curves. Relationship between rating curve and runoff hydrograph.

Surface runoff volume—estimation using SCS curve number method. Annual and seasonal runoff. Flow mass curve.

Streamflow hydrograph—components, factors affecting hydrograph characteristics, elements of the hydrograph, baseflow separation. Unit hydrograph—theory, application, limitations of unit hydrograph theory, Hydrograph, unit hydrograph of different duration, derivation from measured data. Synthetic unit hydrograph—Snyder method. Dimensionless unit hydrograph. Instantaneous unit hydrograph.

Flow routing—methods of reservoir flow routing, channel flow routing using Muskingum method.

Hydrologic design—point and regional frequency analysis of hydrological data. Design flood estimation—selection of a method, steps in estimation of a design flood, analysis of design storms, probable maximum precipitation.

Hydrological models—classification, introduction of selected models.

Recommended Books

- ♦ K Subramanyan. Engineering Hydrology. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- ♦ V P Singh. Elementary Hydrology. Prentice-Hall of India Pvt. Ltd., New Delhi.
- ♦ H M Raghunath. Hydrology—Principles, Analysis, Design. New Age International (P) Ltd., New Delhi.

AG 404

AGRICULTURAL SCIENCE

Group A

Plant science. Morphology of seed, root, stem, leaf, flower and fruit. Anatomy of cells and cells division, tissues and tissue system, internal structures of root, stem and other plant tissues. Physiology of transpiration, mineral nutrition, photosynthesis, nitrogen metabolism, respiration, growth and reproduction. Scope of microbiology, classification, morphology, isolation and propagation, micro-organisms and bacteria, industrial bacteriology.

Soil science: Fundamental principles underlying soil formation and classification, great soil groups of the world. Soil colloids, cation exchange phenomenon. Soil reaction. Soil organic matter, chemistry of carbohydrate. Protein and fat, their decomposition products. Soil fertility management, essential elements with special reference to trace elements. Saline and alkali soils. Physical model of soil, soil water, soil and plant aeration, soil temperature, soil colour. Soil physics and a factor in tillage and soil management.

Group B

Crop production: Past, present and future of crop production in India; Farm crops—their distribution, average and yield; Environmental requirements of crops; Tillage practices; Seeds and seeding practices; Management of soil fertility; Scheduling of irrigation; Pest management, harvesting, threshing, drying and processing; principles underlying crop rotation and cropping systems; Dry farming principles and practices; Cultivation of crops and calendar of farm operations.

Farm management: Management of farms; Basic principles

in management; planning and budgeting decisions in farm machinery use; Farm business, choice of input–output combinations; Farm credit, risk and uncertainty; Agricultural price theory—demand and supply and pricing decisions, consumer equilibrium; Competitive equilibrium. Agricultural employment and wages; Marketing of agricultural products and developments. Marketing functions, marketing agencies; Sales planning and control.

Recommended Books

- ◆ SPDhondyal. Farm Management. Friends Publishers, New Delhi.
- ◆ C Singh. Modern Techniques for Raising Field Crops. Oxford and IBH Publishing Co. (P) Ltd., New Delhi.
- ◆ Handbook of Agriculture. ICAR, New Delhi.
- ◆ T D Biswas and SK Mukherjee. Text Book of Soil Science. Tata McGraw-Hill Publishing Co., Ltd., New Delhi.

AG 405

SOIL AND WATER ENGINEERING

Group A

Properties of soil: Void ratio, dry density, saturation percentage, shear strength of soils, Mohr's diagram and Coulomb's law.

Earth pressure: Rankine's earth pressure theory, active and passive earth pressure, wedge theory, Rebhann's graphical method and Coulomb's method.

Stability of slopes, stability number, stresses under surface loading, compaction, consolidation theory, shallow foundations, safe bearing capacity, seepage through earth dams and flow net construction.

Hydrometeorology. Rainfall and its measurement, analysis of rainfall data, and estimation of rainfall amount and rainfall intensity.

Factors affecting runoff and its measurement, estimation of runoff volume and peak flow, hydrograph types, base-flow separation, flood routing, and flood analysis.

Soil erosion and its effects: Mechanics of wind erosion and its control, and water erosion types and their causes.

Control of water erosion: Biological and engineering methods and their limitations, terraces and bunds, outlets and grassed waterways and their hydraulics.

Methods of gully control: Vegetative protection, temporary and permanent structures and their planning and design.

Rainwater harvesting: Concept and methods of on farm rainwater harvesting, and design and construction of farm ponds.

Group B

Measurement of distance and areas: Division of surveying,

chain surveying, plotting and chain survey, and measurement of areas.

Compass surveying: Instruments, types of traverse and its procedure, bearings, local attractions, magnetic declination, plotting the compass survey.

Plane table survey: Equipment, setting up the plane table, method of surveying and its limitations.

Levelling: Definition of various terminology, levelling instruments (hand level, dumpy level and theodolite), determination of the reduced level (R.L.) plotting of sections and contours, and computation of earthwork.

Use of planimeter and pentagraph, and introduction to minor instruments.

Irrigation and drainage: Irrigation and drainage development in India, causes of inefficient utilization of water resources, soil-water-plant relationships, estimation of reference evapotranspiration (ETO), design of surface irrigation systems and sprinkler irrigation systems, introduction to drip irrigation system, irrigation efficiencies, crop water requirement, and methods of irrigation scheduling.

Drainage of agricultural land: Drainage problems, drainage requirements, drainage investigations, principles and practices of agricultural drainage, important methods of in situ determination of hydraulic conductivity, surface drainage methods, drainage coefficient, subsurface drainage systems, drain spacing formulae (steady state and unsteady state), well drainage, interceptor drains, and mole drainage system.

Recommended Books

- ◆ B C Punmia. Soil Mechanics and Foundations. Standard Book Distributors, Delhi.
- ◆ A M Michael. Irrigation: Theory and Practice. Vikas Publishing House Pvt. Ltd., New Delhi.
- ◆ V V N Murty. Land and Water Management Engineering. Kalyani Publishers, New Delhi.
- ◆ B C Punmia. Surveying. Laxmi Publications, New Delhi.
- ◆ B C Mal. Introduction to Soil and Water Conservation Engineering. Kalyani Publishers, New Delhi.

AG 406

AGRICULTURAL PROCESS ENGINEERING

Group A

Importance and status of agro-processing industries in India. Mass and energy balance in various processing operations. Fluid flow and measurement. Various instruments and appliances for measurement of pressure, flow rate, velocity, temperature, humidity. Motion of particles through fluid, fluidization and its application in agricultural processing operations—pneumatic transport, fluidized bed system.

Cleaning, grading, sorting of granular materials. Mechanical separator-specific gravity, disc, cylinder, centrifugal separators; Centrifuges and cyclone separators; Sieving and size separation. Size reduction and particle size distribution of comminuted particles; energy requirement in size reduction; size reduction equipment and grinding mills. Agitation and mixing of solids and liquids; mixing effectiveness. Vacuum and pressure filtration.

Group B

Drying and dehydration principles; psychometrics; drying theory and methods; driers and dehydration equipment, grain driers, fruits and vegetables dehydrators, milk and milk product drying system.

Grain processing. Principles and equipment; premilling operations and commercial milling of paddy, wheat, maize, pulses and oil seeds selection, operation, maintenance of grain milling equipment and plant; utilization of by-products of grain milling industries.

Grain storage: Principles and methods; Food and storage structures—silo, bins, godowns and cold storage. Mechanical handling system; Conveyors and elevators.

Recommended Books

- S M Henderson and R L Perry. Agricultural Process Engineering. AVI Publishing Co. Inc., Connecticut.
- C W Hall. Processing Equipment for Agricultural Products. AVI Publishing Co. Inc., Connecticut.
- C W Hall. Drying Farm Crops. Agricultural Consulting Associates Inc., Michigan.
- A C Chakraborty. Post-harvest Technology of Cereals, Pulses and Oil Seeds. Oxford & IBH Publishing Co., Kolkata.
- C J Geankoplis. Transport Processes and Unit Operations. Prentice Hall of India (P) Ltd., New Delhi.

AG 407

DESIGN OF AGRICULTURAL STRUCTURES

Group A

Farm structures. Environmental factors affecting design and layout of farm structure. Farm shed planning. Functional requirement of buildings for special uses.

Floor and roof loads. Unit weights of materials, estimation of dead and live loads, foundations—Rankine theory of earth pressure design of foundations and retaining walls.

Materials for construction and their design properties. Analysis of forces and principles of design of different kinds of beams and columns. Most common types of roof trusses—graphical and analytical procedure for evaluating forces—design of joint members and gusset plates-truss connections.

Techniques of good concrete making—design of singly reinforced beams, doubly reinforced beams and T beams. Shear

distribution in reinforced concrete sections. Design of columns and column footings.

Group B

Design of building for special uses, storage structures, dairy farms and poultry houses. Advanced farm structure: Analysis of forces, design of trusses.

Grain pressure theories. Codes of practice for design and construction of steel and RCC column footing, beams, floors and slabs. Design of silos, warehouses and cold storage.

Rat proofing, fumigation and ventilation. Aeration system for various storage structures. Grain handling equipment and their design and operation features.

Recommended Books

- Pillai . Reinforced Concrete Design. Tata Mc-Graw Hill, New Delhi.
- Sadhu Singh. Refrigeration and Air-conditioning. Khanna Book Publishing Co. Ltd., New Delhi.
- H J Barre and L L Samuel. Farm Structure. Wiley International.

AG 411

REFRIGERATION AND AIRCONDITIONING

(See page 63, subject MC 411)

AG 412

NON-CONVENTIONAL ENERGY SOURCES

Group A

Different forms of non-conventional energy sources—solar, biogas, wind, tides, geothermal, etc. Integrated energy package using solar, wind, biomass, etc. Comparative study of non-conventional energy sources. Economics.

Solar energy. Solar collector, selective surfaces, solar thermal process. Design of solar system for heating, cooling, distillation, drying, dehydration, water pumping and power generation for application in agriculture. Utilisation of wind energy for generating electrical and mechanical power. Types of wind mill and their characteristics. Mechanics of wind mill. Design of wind mill.

Group B

Ocean thermal energy conversion, geothermal energy, hot spring and steam injection. Power plant based on OTEC and geothermal springs.

Basic bio-conversion mechanism, recycling of agricultural waste. Simple digester. Microbiological conversion plant materials to fuels. Biochemistry of anaerobic fermentation of biomass. Design of biogas system for heating, lighting and running I C engine. Economics of biogas utilisation.

Photovoltaic device, limitation of photovoltaic efficiency. Fuel cells—development in fuel cells and applications.

Fusion energy. Control led fusion of hydrogen and helium, etc. Present status and problem.

Recommended Books

- ♦ S P Sukhatme. Solar Energy: Principles of Thermal Collection and Storage. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- ♦ Chandra. Non-conventional Energy Sources. Khanna khannabooks.com.
- ♦ Biomass Combustion Technologies—Technical Service. FAO.
- ♦ Energy Conversion and Renewable Energies for Greenhouse Heating—Technical Service, FAO.

AG 413

FOOD ENGINEERING

Group A

Elements of food engineering: Composition and proximate analysis of food products. Deteriorative factors and their controls.

Physical, chemical and biological methods of food preservation. Water activity and its control changes undergone by the food components during processing.

Flow process chart for processing various agricultural produce like grain, milk, meat, poultry, fish and vegetables. Identification of common unit operations in all these processes.

Classification into mechanical and physical unit operations. Mechanical unit operations: Cleaning, sorting, sedimentation and separation grading, filtration size reduction expression, material handling system and devices in food processing.

Group B

Concentration and dehydration of foods: Properties of water as a constituent of food. Water activity and its measurement. Factors affecting water activity and control of food spoilage.

Membrane and non-membrane concentration of foods. Ultrafiltration and reverse osmosis of liquids. Evaporation and boiling of liquid foods, batch and continuous type evaporators. Evaporators for high viscosity liquid foods.

Simultaneous heat and mass transfer in solid and liquid foods during dehydration. Constant and falling rate drying of solid materials. Evaporation of liquid droplets. Spray and foam mat and drum drying. Freeze dehydration. Packaging of dehydrated foods.

Design of fluid conveyance system, pipe, sanitary pipe fittings and valves, CIP system. Design of food processing

equipment including heat exchange equipment. Plant design and layout.

Recommended Books

- ♦ O R Fennema. Food Chemistry. Marcel Decker Inc., New York.
- ♦ W C Frazier and D C Westcott. Food Microbiology. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- ♦ JG Brenner. Food Engineering Operations. Applied Science Publishers, London.
- ♦ C J Geankoplis. Transport Process and Unit Operations. Allyn and Baker, Boston.
- ♦ O R Fennema. Principles of Food Science. Marcel Decker Inc., New York.

AG 414

BIOPROCESS ENGINEERING

Group A

Biochemical and biological reaction systems, bioenergetics, kinetics of enzyme catalyzed reaction, Michaelis-Menten equation and its various modifications, microbial growth kinetics, enzyme kinetics with free enzyme and immobilized enzyme, studies of growth pattern in batch culture and CSTR system, mixed culture system, biological wastewater treatment, activated sludge process, biogas plant design and development.

Group B

Bioreactors and their types, batch CSTR, bubble column, airlift fermenter, multistage system, aeration and agitation, design and analysis of above reaction systems, media and air sterilization, thermal death kinetics, downstream processing, recovery and purification of products, alcohol, acid, antibiotics and enzymes.

Recommended Books

- ♦ M D Trevan, S Boffy, K H Goulding, P Stanbury (Eds.). Biotechnology: The Biological Principles. Tata-McGraw Hill Publishing Co. Ltd., New Delhi.
- ♦ J E Bailey and D E Ollis. Biochemical Engineering Fundamentals. McGraw-Hill International.
- ♦ Prescott and Dunn. Industrial Microbiology. CBS Publishers & Distributors, Delhi.
- ♦ Metalf and Eddy. Wastewater Engineering Treatment and Disposal Reuse. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- ♦ S Aiba, A E Humphrey and N F Millis. Biochemical Engineering. Academic Press Inc., New York.
- ♦ D J Bell, et. al. Downstream Processing. Springer-Verlag, Berlin.

AGRICULTURAL MACHINERY

Group A

Mechanisms and dynamics of agricultural machines: Mechanism and conversion of motion. Analysis of degree of freedom. Two- and three-dimensional kinematics of mechanisms. Synthesis of link mechanisms. Velocity and accelerations. Analysis of mechanisms. Kinematics representation and analysis of mechanisms used in crop production and processing machines. Synthesis of cams and gear trains. Static and inertia forces in agricultural machines: Balancing of reciprocating and rotating parts. Dynamic analysis of belts, ropes and chains drives.

Farm machinery: Manually drawn small tools and devices, bullock-drawn implements, tractor-drawn implements and machines.

Basic design principles of farm machines, implements and tools, design and selection of primary and secondary tillage implements. Design of seeders, planters, and transplanting machines. Design of harvesting and threshing machines. Design of transport trailers.

Group B

Agricultural tractors: Types of farm tractors, tractor clutches and brakes. Power transmission systems and final drives. Traction theory. Mechanics of farm tractor chassis. Hitch systems and hydraulic controls, steering system of tractors, tractor tests and performance. Tractor power cost estimating. Human factors in tractor design.

Maintenance and repair of tractors and machinery: Preventive maintenance of tractors and agricultural implements. Repair and overhaul of the tractor engines and implements. Adjustment and repairs of hydraulic systems used in tractors. Maintenance and retreading of tyres. Machinery management.

Recommended Books

- ♦ Jagdish Lal. Theory of Mechanisms and Machines. Metropolitan Book Co. Pvt. Ltd., New Delhi.
- ♦ A K Sivastava, E C Goering and R P Rohrbach. Engineering Principles of Agricultural Machines. ASAE Publication, USA.
- ♦ R A Kepner, B Roy and Barger. Principles of Farm Machinery. CB S Publishers & Distributors, Delhi.
- ♦ J B Liljedahl, W M Carleton, P K Turncoats, D W Smith. Tractors and their Power Units. John Wiley and Sons, New York.

DRAINAGE ENGINEERING

Group A

The need for land drainage and design considerations for land drainage.

Frequency and regression analysis of rainfall: Frequency analysis, frequency-duration analysis, theoretical frequency distributions, and regression analysis.

Estimating peak runoff rates.

Collection, processing and interpretation of groundwater data.

Determination of saturated hydraulic conductivity by correlation, hydraulic laboratory, small-scale in-situ and large-scale in-situ methods, small scale in-situ methods auger hole and inverted auger-hole methods.

Components of water balances, water balances of the saturated and unsaturated zones, integrated water balances, equations for water and salt balances, processing and interpretation of basic water balance data, water balance analysis with flow nets.

Subsurface drainage systems: Steady state equations, Hooghoudt and Ernst equations. Unsteady state equations: Glover-Dumm and De Zeeuw-Hellinga equations. Special drainage situations: Drainage of sloping lands, interceptor, relief and mole drains, types of subsurface drainage systems, design of pipe drainage systems, installation of pipe drains, hydraulics of drainage pipes, mole drainage.

Group B

Surface drainage systems: Bedding and traditional land forming system, land grading and land levelling calculations: plane and profile methods, field drains and field laterals, surface drainage systems for sloping areas: cross-sloped drainage system, standard erosion control terraces, and water disposal in sloping areas.

Tubewell drainage system: Tubewell drainage versus other subsurface drainage system, basic equations of well field in triangular and rectangular patterns, basic equations of partial penetration and semi-confined aquifers, design considerations, well-field and well design.

Salinity in relation to irrigation and drainage, electrical conductivity and soil water extracts, exchangeable sodium, classification of salt-affected soils, crop growth affected by salinity and sodicity, salt balance of the root zone: salt equilibrium and leaching requirement, salt storage, salt equilibrium and storage equations expressed in terms of electrical conductivity, effect of slightly soluble salts on the salt balance, leaching process in the root zone: leaching efficiency coefficient and leaching efficiency coefficient in a four-layered profile, sodium hazard of irrigation water, reclamation of salt-affected soils: leaching techniques, leaching equations and chemical amendments.

Influence of irrigation on drainage: Water balances and irrigation system efficiencies, combined irrigation and drainage systems.

Environmental aspects of drainage: Environmental impact, side effects inside the project area: loss of wetland, change of the habitat, lower water table, subsidence, salinization, acidification, seepage, erosion, leaching of nutrients, pesticides,

and other elements and health, downstream side effects; disposal of drainage effluent, disposal options, excess surface water and seepage from drainage canals, environmental impact assessment.

Recommended Books

- ♦ Drainage Principles and Applications. International Institute of Land Reclamation and Improvement, Wageningen, the Netherlands Publication No. 16, 1994.
- ♦ J N Luthin. Drainage of Agricultural Lands. Number 7 in the series. Agronomy of the American Society of Agronomy, USA.
- ♦ J V Schifgaard. Drainage for Agriculture. Number 17 in the series. Agronomy of the American Society of Agronomy, USA.
- ♦ Drainage Manual: Water Resources. US Department of the Interior Technical Publication. Oxford & IBH Publishing Co. (P) Ltd., New Delhi.
- ♦ USDA. Drainage of Agricultural Land. Scientific Publisher, Jodhpur.

AG 422

IRRIGATION ENGINEERING AND HYDRAULIC STRUCTURES

Group A

Water resources of India and its utilization for irrigation: Scope and significant issues.

Water distribution pattern in canal command areas: Gross command area, cultural command area; Intensity of irrigation; Delta, duty, base period and their relationships.

Measurement of irrigation water in channels and pipes: Weirs, flumes, and orifices, meter gates, Venturi meters and pilot tubes.

Land grading and field layout: Land grading and land levelling procedures and equipment.

Plant-soil-atmosphere-water interactions: Consumptive and evapotranspiration; methods to determine evapotranspiration; Irrigation requirements; Soil water potential and its measurement; Irrigation scheduling, irrigation efficiency.

Irrigation methods: Border, check basin, furrow, sprinkler and drip irrigation, adaptability, hydraulics and design of irrigation methods.

Group B

Diversion head works: Layout of a diversion head works and its components, weirs and barrages, gravity and non-gravity weirs, diversion weirs and its types: masonry weirs, rock fill weirs, concrete weirs.

The canal head regulator and silt control devices.

Water control and diversion structures: Check gates, portable check dams, turnouts spills, siphon tubes.

Structures to control erosion in irrigation channels: Concept of hydraulic jump and its usefulness in hydraulic structure design, open drops structures, pipe drop structures, chute spillway.

Structures at channel crossing: Flumes, culverts and inverted siphons.

Water conveyance systems: Canal of regime channel concepts, Kennedy's and Lacey's theory. Design of field open channels using uniform flow concepts. Design of underground pipeline.

Recommended Books

- ♦ A M Michael. Irrigation Theory and Practice. Vikas Publishing House Pvt. Ltd., New Delhi.
- ♦ V V N Murty. Land and Water Management Engineering. Kalyani Publishers, New Delhi.
- ♦ Gupta. Elements of Environmental Pollution Control. Khanna Books, Delhi.
- ♦ G O Schwab, D D Fangmeier, W J Elliot and R K Frevert. Soil and Water Conservation Engineering. John Wiley & Sons Inc., New York.

AG 423

GROUNDWATER ENGINEERING

Group A

Groundwater flow: Elementary concepts and definitions, occurrence of groundwater, aquifer properties, saturated and unsaturated zones of flow.

Elementary theory of groundwater movement, equation of continuity, Euler's equation, Laplace's equation, Kozeny-Carman equation, Darcy's law.

Groundwater flow in homogeneous and isotropic medium, stream lines and equipotential lines, flow nets for aquifer and wells.

Stress in aquifer, fluid forces in porous media, capillary forces, Dupuit-Fordheimer approximation, Boussinesq equation for flow through unconfined aquifer.

Mechanics of well flow, steady radial flow to a well, interference between wells, method of images.

Unsteady flow: Analysis of pumping test data by Theis, Jacob, Chow and Hantush's methods, hydraulics of partially penetrating wells.

Group B

Management of saline aquifers, concepts of sea water intrusion, causes and remedial measures, hydrostatic and hydrodynamical approach.

Numerical and experimental methods in groundwater flow, finite difference method, model studies; sand tank and electrical analogue models.

Surface and subsurface methods of groundwater investigation, types of wells, drilling methods, choice of methods, drilling equipment and tools.

Well installation: Casing pipes and screens, gravel filters, well development, testing of wells, concept of safe yield, water-well corrosion.

Installation of pumps: Selection criteria of different pumps; centrifugal, turbine and submersible pumps, matching of pump with well.

Chemical properties of groundwater; mineral analysis, hardness, electrical conductivity, pH, dissolved material, water quality requirement for drinking and irrigation purposes.

Recommended Books

- ♦ H M Raghunath. Groundwater. New Age International (P) Ltd., New Delhi.
- ♦ D K Todd. Groundwater Hydrology. John Wiley & Sons, New York.
- ♦ A M Michael and S D Khepar. Well and Pump Engineering. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- ♦ B C Mal. Introduction to Soil and Water Conservation Engineering. Kalyani Publishers, Ludhiana.

AG 424

SOIL CONSERVATION ENGINEERING

Group A

Significance of erosion, extent of erosion, types of erosion—geological and accelerated, factors affecting soil erosion, impact of soil erosion on productivity and economy. Land capability classification.

Rainfall analysis, rainfall and runoff relationship, rainfall and runoff frequency analysis, estimation of runoff volume and peak runoff.

Soil loss estimation: Universal Soil Loss Equation (USLE), Modified Universal Soil Loss Equation (MUSLE), application of USLE and MUSLE for soil loss estimation from agricultural watersheds.

Wind erosion: Factors affecting wind erosion; mechanics of movement; wind erosion control measures (vegetative, tillage and mechanical); types of water erosion (splash, sheet, rill, gully and stream bank erosion); factors affecting water erosion; classification and types of gully erosion, mechanics of sediment movement.

Water erosion control and practices: Biological (crop rotation, cover cropping, contour farming, strip cropping, mulch tillage or stubble mulching) and mechanical measures (terracing, bunding, and vegetative waterways).

Terrace types (bench terrace and broad base terrace), design of terrace system—terrace spacing; cross-section; length, channel

capacity and layout.

Contour and graded bunds and their design, types of vegetated waterways and their design.

Gully control practice: Vegetative measures (sod flumes, sod checks and plantation), temporary gully control structures (check dams) and their design.

Group B

Permanent gully control structures: Types (drop spillway, drip inlet spillway and chute spillway) and their design (hydrologic, hydraulic and structural).

Energy dissipators—hydraulic jump, different types of energy dissipators, auxiliary devices.

Earthen dams—uses and types, method of construction, causes of failure, design criteria, seepage analysis, flow net, determination of seepage using flow-net, determination of seepage line under horizontal filter and without filter.

Farm pond—types, site selection and design.

Rain water harvesting—methods and design criteria.

Watershed management—definition, classification, watershed management programmes, watershed models used for soil conservation work.

Recommended Books

- ♦ R Suresh. Soil and Water Conservation Engineering. Standard Publishers and Distributors, Delhi.
- ♦ V V N Murty. Land and Water Management Engineering. Kalyani Publishers, New Delhi.
- ♦ O P Gupta. Elements of Environmental Pollution Control. Khanna Books, Delhi.
- ♦ G O Schwab, D D Fangmeier, W J Elliot and R K Frevert. Soil and Water Conservation Engineering. John Wiley & Sons, New York.

AG 425

WATER RESOURCES ENGINEERING

Group A

General: Water resources potential of the country. Necessity for conservation and development of country's water resources. Need for multipurpose and single purpose projects for municipal and industrial water supplies, irrigation, power, navigation and flood control.

Water requirement: General requirements of water for municipal and industrial water supplies, irrigation, hydel power projects, navigation and waste disposal.

Hydrology: The hydrologic cycle, precipitation, streamflow, evaporation and transpiration. Hydrograph and unit hydrograph analysis. Estimation of runoff volume, storage routing. Use of rainfall, runoff and streamflow data. Flood frequency and flood formulae. Stochastic hydrology.

Sources of water: Groundwater occurrence, hydraulics, shallow and deep tubewells, yield of a well. Infiltration galleries.

Surface water: Necessity of storage, fixing capacity, sedimentation of reservoirs, flood routing.

Flood control: Methods of estimation of flood discharge, flood control reservoirs, flood walls, channel improvement, evacuation and flood zoning, economics of flood control.

Group B

Water quality: General requirements for domestic, industrial and irrigation purposes. Need for control of industrial and municipal effluents discharge to water sources used for drinking and irrigation. Hazardous salts, soil suitability, soil moisture, texture and structure.

Desalination of water: Various methods, cost aspects of desalination, re-use of water.

Conveyance of water: Intakes, choice of site on rivers and reservoirs. Outlet through earthen and masonry dams—location, construction and precautions.

Planning water resources development: Objective and requirements, project formulation, multipurpose projects. Engineering economy in water resources planning, cost allocations.

Groundwater and tubewells: Origin of groundwater, prospecting and testing of groundwater. Hydraulics of wells. Types of wells and their construction, drilling methods, types of boring equipment, tools and their use. Well curbing, casing pipes and well screens, design of gravel filters. Well development, testing of wells.

Recommended Books

- RK Linsley and JB Franzini. Water Resources Engineering. McGraw-Hill International.
- O P Gupta. Elements of Environmental Pollution Control. khannabooks.com, Delhi.
- B S N Raju. Water and Waste Water Engineering. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

AG 431

FARM MACHINERY

Group A

Agricultural systems engineering: Systems design, analysis and control in agricultural engineering. Study of systems design techniques for agricultural problems—need analysis, activity analysis, and synthesis of solutions and feasibility study including modeling and simulation.

Farm machine dynamics: Dynamics of farm machine elements. Vehicle dynamics in agricultural engineering: (a) Vibration, (b) Lumped model systems, (c) Transient response of tractors. Particle dynamics in agricultural engineering: (a)

Trajectory of seeds and granular fertilizer, (b) Dynamic considerations for flail knives and their applications.

Maintenance and repair of tractor and machinery: Preventive maintenance of tractors and agricultural implements. Repair and overhaul of the tractor engines and implements. Adjustment and repair of hydraulic systems used in tractors. Maintenance and retreading of tyres. Drawbar and hitches. Tractor and machinery management. Cost of using tractors.

Group B

Land reclamation and earthmoving machinery: Land reclamation—methods of clearing tropical forest and scrub jungle, selection of machinery, reclamation of weed infested lands—crawler tractors, bulldozers, angle and tree dozers, power control units, rooters and root rakes—scrapers and graders. Construction of bunds, terraces and ditches. Analysis of cut and fills machinery for field and base workshop. Stocking of spares and mechanical store handling—cost of operation.

Various water-lifting devices: Pumps and their classification; basic theory of pumps—ideal head, torque, horsepower equations. Circulatory flow, percolation, losses and coefficients, performance curves, dimensionless parameters, specific speed, efficiency and selection. Cavitation parameter, suction head, changes in pump characteristics due to changes in fluid properties, speed impeller diameter, etc. Design of radial type centrifugal pumps—impeller dimensions and vane angles, design of vanes and volute. Multistaging pump testing model prototype correlation, pump installation under different conditions, pump selection and economics.

Recommended Books

- B Roy, R A Kepner and E L Berger. Principles of Farm Machinery. John Wiley and Sons, New York.
- J M Shippen, C R Ellin and C H Clover. Basic Farm Machinery. Pergamon Press Ltd., UK.
- A K Srivastava, C E Georing and R P Rohruch. Engineering Principles of Agricultural Machinery. ASAE Publication, Michigan, USA.

AG 432

NON-CONVENTIONAL ENERGY SOURCES

(See page 117, subject AG 412)

AG 433

FARM MACHINERY DESIGN

Group A

Basic design principles of farm machines, farming operations and related machines. Mechanical design of power transmission, fluid power.

Design of primary and secondary tillage implements procedures and machines for seeding, precision planting and transplanting.

Design and application methods for dry chemicals, application of liquid chemicals, methods and equipment for fertilizer distributors. Design of spraying equipment—hand held, backpack type and tractor drawn.

Design of harvesting machines for cereals, pulses, root crops, fruits, nuts, vegetables and forage.

Group B

Design of manually operated threshers, power operated threshers for different crops. Design of farm transport equipment.

Design of equipment and machines for conveying of agricultural materials. Screw conveyors, pneumatic conveyors. Bucket conveyors and forage blowers. Test codes. Performance indices.

Selection of machines for various farming systems. Farm machinery management, machinery cost, replacement, breakeven hours of use of machines and matching of machines to power sources.

Recommended Books

- M P Poonial & S C Shanna. Mechanical Engineering. Khanna Publishing, New Delhi.
- Sadhu Singh. Machine Design and Machine Design Data Book, khannabooks.com.
- G Krutz, L Thompson and P Claar. Design of Agricultural Machinery. John Wiley and Sons, New York.
- B Roy, R A Kepner and E L Berger. Principles of Farm Machinery. John Wiley & Sons, New York.
- H Bernacki, J Haman and C S Kunafowski. Agricultural Machines—Theory and Construction—Vols I & II. USDA Publication.

AG 434

TRACTOR AND TRACTION EQUIPMENT

Group A

Power units of tractors. Governors and governor controls.

Tractor engine performance characteristics. Tractor tests and performance. Mechanics of traction and transport devices.

Mechanics of farm tractor chassis. Tractor clutches and brakes. Power transmission systems and final drives. Hitch systems and hydraulic centres. Steering systems.

Human factors in tractor design. Tractor power cost estimation.

Group B

Grading of sloppy lands. Principles and mechanisms of crawler mounted tractors. Dump trucks and their mechanism and hiring equipment.

Earth diggers and ditchers. Bulldozers and scrapers. Elevators and self-powered graders.

Automation of earthmoving and grading machines. Boring machines. Different methods of boring tubewells.

Recommended Books

- JB Liljedatil, WM Carleton, PK Turnquist and D W Smith. Tractor and their Power Units. C B S Publishers & Distributors, Delhi.
- Ben D Moses and K R Frost. Farm Power. John Wiley International.
- Haris, Pearson and Smith. Farm Machinery and Equipment. McGraw—Hill International.

AG 435

DESIGN OF MACHINE ELEMENTS

(See page 62, subject MC 407)

ARCHITECTURAL ENGINEERING

Ancient Indian Architecture—A Pillar of Civilization

Any Indian familiar with the history of Indian civilization, culture and heritage feels proud of India's outstanding achievements in the fields of architecture and civil engineering. The whole of India is dotted with magnificent structures comprising of stupas, temples, mosques, churches, palaces, fortresses, etc. which have stood for centuries bearing testimony to Indian ingenuity, creativity, aesthetic sense and professional skills in the above fields. Be it the temples at Ellora or the Taj Mahal at Agra, examples abound to make it a wonder on architectural excellence, aesthetic, engineering skills in design, workmanship and construction technology.

Architect and New Construction Materials & Techniques

The architect of today is both an artist and an engineer, who must synthesise his architectural ideas with scientific knowledge of design and construction of civil structures. He must be conversant with the available resources in labour, techniques and materials to produce a harmonious, durable and functional structure in line with his architectural concept.

Architecture has always been constrained by the availability of materials and restricted by techniques of design and construction. Discovery of newer materials of construction along with the development of sophisticated design and construction technology, steel-framed superstructures and reinforced and prestressed concrete have provided the architect an unlimited scope to use their creative imagination to put up structures which not only display architectural elegance but also meet the functional requirements without jeopardizing structural safety in any manner. Thus, the modern structures represent a harmonious blending of art, aesthetics, environmental considerations, application of sophisticated design and

The term Architectural Engineering is used to indicate a field embracing all the engineering aspects of building design, including mechanical and electrical equipment, acoustics, illumination, air conditioning, safety measures and layout. When used in this broader sense, architectural engineering connotes building structures as its speciality, since the growing complexity of other fields generally requires their engineering design to be accomplished by specialists trained in the pertinent branches of engineering. However, the coordination of the structural, mechanical and electrical aspects with each other and with the architectural scheme is often the responsibility of the architectural engineer.

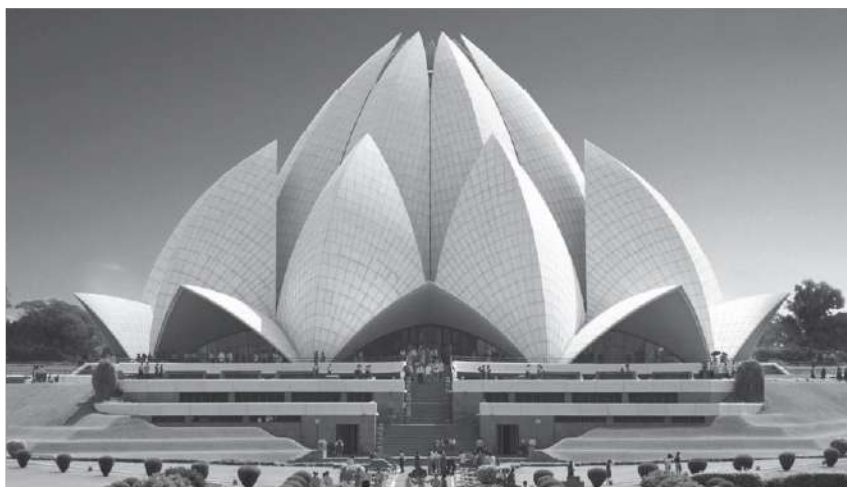
According to Nervi, "The themes submitted to the designer are every day loftier and of greater structural importance. The schools of architecture will fail in their aims and architecture will become empty formalism, unless we give our young architects the kind of training necessary to tackle such problems. I believe, therefore, that the schools of architecture should above all teach structural correctness, which is identical with functional, technical and economic truthfulness and is a necessary and sufficient condition for satisfactory aesthetic results. The aesthetic results achieved by these means usually suffice even if they do not reach the superior heights of art".

construction technology and expression of modern culture.

It is understandable that architecture and engineering play complementary roles from conception to construction, though the relative importance of either would vary from structure to structure. In the case of a temple, a church or a mosque, the architectural considerations may outweigh the engineering requirements of economy but the same is reversed in the case of a bridge, a hospital or an industrial building. The fact remains that for proper planning, designing and erecting a structure, its intended functions, architectural needs, quality of construction, durability and overall cost have all to be weighed and a judicious application of the sciences of architecture and engineering have to be made. Thus, an architect, to be true to his profession, needs to be an engineer as well.

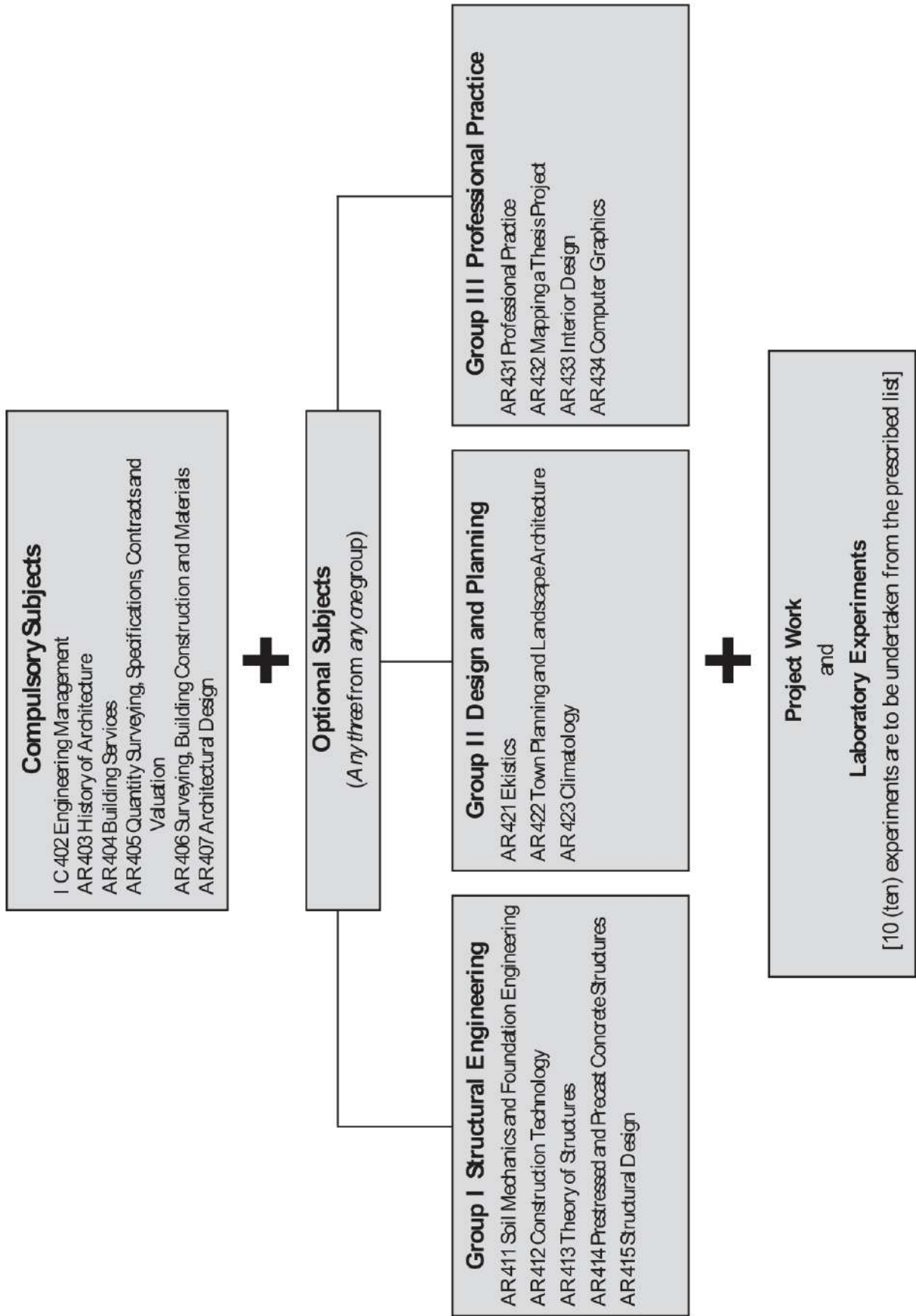
Role of Architectural Engineers

In the planning and execution of large and complex civil engineering works, India has made rapid strides in the last two decades. It is now recognised that architecture and aesthetics are no longer confined exclusively to buildings but play an important part in the construction of bridges, flyovers, warehouses, factories, special structures for hydro/thermal power projects, marine structures, landscaping along highways, etc.



Lotus Temple of Delhi

AGRICULTURAL ENGINEERING



ARCHITECTURAL ENGINEERING

IC 402

ENGINEERING MANAGEMENT

(See page 13, subject IC 402)

AR 403

HISTORY OF ARCHITECTURE

Group A

Indian architecture Prehistoric and primitive architecture. Study of art and architecture in Indus Valley. Vedic village—social conditions and way of life. Rockcut temples, viharas, caves, limitations of implements. Buddhist, Jain and Hindu architecture—reflection of religious thought and way of life.

Islamic architecture Cultural differences and similarities of local inhabitants and invaders. Influence of advanced technology—domes, arches, vaults, conversion of places of worship into new needs of invaders.

Study of early buildings in India expressing vigour in the form of buildings. Study of advancement of building technology and space conception in places like Bijapur, Mandu, Fatehpur Sikri.

Study of the examples of Moghul architecture such as tomb, forts and palaces, and the development of various provincial styles of architecture like Sudh, Bijapur, Gujarat, etc.

Group B

Foreign architecture Developments of styles and forms in Europe, Egypt, West Asia, Greek and Roman architecture. Developments in Renaissance and Baroque periods. Integration of indoor and outdoor frames, study of development of art forms with respect to cultural events.

Modern architecture Role of steel, RCC, aluminium, plastics, glass and timber technology in modern buildings. Modern skyscrapers, Chicago school works, Frank Lloyd, Mies van der Rohe, Le Corbusier, Nervi, etc.

Recommended Books

- w P K Acharya. A Dictionary of Indian Architecture.
- w P Brown. Indian Architecture—Buddhist and Hindu.
- w B Fletcher. A History of Architecture on the Comparative Method.
- w A D F Hamlin. A Text Book of History of Architecture.
- w P Brown. Indian Architecture—Islamic.

AR 404

BUILDING SERVICES

Group A

Sanitation: Importance and basic approach. Location of sanitary units. House drainage system. Sewers—materials, workmanship, septic tanks, testing of drains, gradients, ventilation, local bye-laws, maintenance traps of various types. Planning and layout of lavatory blocks, different types of sanitary fittings and their installation, selection and testing of fittings. Layout of sewers and drains in various types of buildings.

Domestic water supply: Meter chambers, overhead and underground tanks, pump houses, installation, selection and testing of pressure fittings. Domestic hot water supply. Layout of water supply system in buildings of various types.

Drainage, sewerage and sewage disposal: Sewage disposal systems for small projects, treatment plants, gas plants, disposal of refuse, incinerator, refuse disposal in high rise buildings, treatment of industrial refuse. Refuse and pollution problem. External drainage and sewerage systems.

Acoustics: Basic problems, criteria and terminology. Transmission of sound in rooms, speech privacy between offices, coefficient of sound absorption, noise reduction, co-efficient, classification and selection of acoustical materials, acoustics of auditorium, schools, religious buildings, recommendations for acoustical treatment.

Group B

Air-conditioning, heating and ventilation: Different types of heating equipment, viz., radiators, convectors, electric radiant panel heaters. Requirements of comfort conditions, temperature control, humidity control. Mechanical ventilation, plenum system, exhaust system, fan exhaust and blower fans, air filters of different types, air-conditioning plants and layout of ducts for cinema, auditoriums, offices, hotels, etc.

Fire fighting: Cause of fire, spread of fire, fire-fighting equipment and different methods of fire fighting, sprinklers, fire regulations and requirements of fire insurance, fire-fighting in high rise buildings.

Electrical services: General distribution of electric power in towns, sub-stations for small schemes and industrial units, meter rooms, electrical installations in buildings, electrical wiring—different materials employed and specifications, electrical appliances and electrical services, earthing, bye-laws pertaining to electrical installations. Different types of artificial lighting systems. Lighting systems for residential buildings, public buildings, hotels, cinemas, hospitals, exhibition halls, libraries, schools, colleges, scientific laboratories, etc.

Recommended Books

- w The Use of Architectural Acoustical Materials—Theory and Practice. American Institute of Acoustics.
- w ASHRAE Guide and Data Book. American Society of Heating, Refrigeration and Air-conditioning Engineers.
- w C M Harris. Noise Control Handbook. Mc-Hill International.
- w B Louis. Design of Plumbing and Drainage Systems. Industrial Press, New York.
- w H M Sharp. Introduction to Lighting

AR 405

QUANTITY SURVEYING, SPECIFICATIONS, CONTRACTS AND VALUATION

Group A

Estimating Introduction, definition, objective, scope and importance. Approximate estimate on plinth area basis, estimate based on cubic content method as approved by Indian Bureau of Standards. Estimate based on detailed quantities and mode of measurements as per BIS 1200.

Quantity surveying Bill of quantities, methods of taking off quantities, preparation of abstract. Units of work and rate analysis. Quantities for excavation, foundations and quantities for load bearing structures. Quantities of RCC and prestressed structures. Quantities for steel structures. Quantities for services—plumbing, water supply sewers, electrical services, air-conditioning and acoustic treatment, lifts, etc. Quantities for land development and access roads. Quantities for landscape work. Measurement of completed works in accordance with practice stipulated by National Building Code.

Rate analysis Rate analysis of important items like materials, labour, plant and contractor's profit.

Specifications Importance of specifications, methods of developing specifications, typical specifications for building items, standard reference.

Group B

Execution of contract: Nature of supervision—periodical/full time. Appointment of clerk of works, resident engineer, resident architect. Quality control and workmanship. Powers and duties, appointment of subcontractor, appointment of specialists and consultants and co-ordination of their work. Payments, earnest money, security deposits, interim and final bills.

Problems arising out of operation of contract. Extra items, variations. Progress and stages of execution. Termination of contract. Certificate of completion of contract, arbitration, forms and procedures.

Valuation: Introduction—techniques of valuation, elements of valuation and factors affecting valuation. Methods, valuation

of landed property and building property, rate of interest for sale, purchase, mortgage, capital gain tax, wealth tax, estate duty and death duty. Compensation—valuation for compensation on acquisition, compensation under central and state legislation, relevance of Town Planning Act. Types of valuation—valuation for renewal of lease, extension of lease, standard rent, easement rights, dilapidation, insurance, estate development and advice of investment policy. Report—preparation of feasibility report, valuation report, awards, etc.

Recommended Books

- w B N Dutta. Estimating and Costing in Civil Engineering: Theory and Practice. UBSPublishers & Distributors, New Delhi.
- w P L Bhasin. Quantity Surveying. S Chand & Co. Ltd., New Delhi.
- w S C Rangwala. Valuation of Real Properties. Charotar Publishing House, Anand (Gujarat).

AR 406

SURVEYING, BUILDING CONSTRUCTION AND MATERIALS

Group A

Ideas about chain survey, compass survey, plane table survey, levelling and theodolite survey.

Curves Simple, compound, reverse and transition curves. Vertical curves for roads and railways. Curve ranging. Setting out curve by offset and by methods of deflection angles. Length of curve calculation (accessible and inaccessible), curve tables.

Setting out building works.

Building Construction

Component-brick masonry. English and Flemish bonds. Other types of bonds. Solid and hollow blocks. Stone masonry of different types; types of finishes; pointing, plastering and finishes. Timber partition walls, doors, windows, and skylights of timber and metals. Lintels, floor finishes, tiles, Indian patent stones, marble, Shahbad and Tandur tiled flooring.

Floor systems Beam and slab floors, flat slab, rectangular and diagrid systems, present units, hollow tile flooring, timber flooring, precast floors.

Access Various types of staircases, ramps, lifts, escalators, emergency exits, bye-law requirements. Principles of barrier-free access to handicapped persons.

Basements Planning, design and construction of basements, waterproofing, disposal of seepage, security measures in bank vaults, precautions against flooding and fire, groundwater uplift in basements.

Roofs Study of various types of roofs, steel, timber, and pre-cast trusses, corrugated sheets of steel, aluminium, etc., tiled roofs, RCC roofs, domes and shells.

Finishes Different types of internal and external finishes, exposed, textured and plastered concrete work, plastering—plain, rough set, textured, fibrous, pebbledashed, gypsum and plaster of paris, gunniting, their specialities and appropriate applications. Use of tiles for external finishing and other cladding materials.

Group B

Bricks and tiles—manufacture, types, quality requirements, tests. **Stoneware products**—manufacture, quality requirements, tests, joints. **Limes and cements**—types, manufacture, requirements of IS codes and admixtures. **Stones and sand**—igneous, metamorphic and sedimentary stones, geologic formations, strengths and tests. **Sands and fine aggregate**—sieve analysis, requirements for building purposes, BIS standards. **Rural materials**—bamboo, thatch, hay, coir, casurina, palmyra, etc.—their study and uses in rural construction. **Stabilized soil construction**, innovation and improvements of their characteristics for building purposes. Current trends in the use of mud for house building.

Metals and alloys Cast iron, mild steel, high tensile steel, special steels, manufacture and requirements of BIS tests. Bar and standard sections. Electrodes, aluminium, brass, copper, bronze, lead, zinc and gun metal, architectural mix.

Timbers General properties, common methods of preservation, varieties of timber in common use. Essential requirements for building and furniture work. Tests required by BIS laminates, plywood, joints and methods of joining.

Paints, varnishes and polishes Purposes, types, choice of paint, cement paints, preparation of surfaces, methods of application.

Insulating materials Fibreboard, thermocol, asbestos, softboard, suitability for insulation against heat, sound and electricity. Fire resistance, requirements of BIS, methods of fixing.

Plastics Classification, types, merits and demerits, epoxy, polymer, their engineering and architectural uses, fibre reinforced plastics.

Testing of materials commonly used in building industry.

Building glass: Varieties, thickness.

Recommended Books

- w S K Sharma. Civil Engineering Construction Materials. Khanna Books Publishing, Delhi.
- w R C Smith. Materials of Construction. McGraw Hill International.
- w J K McKay. Building Construction—Vols I to V. Longmans.
- w S K Sharma and B K Kaul. Text-book of Building Construction. S Chand & Co. Ltd., New Delhi.

AR 407

ARCHITECTURAL DESIGN

Group A

Basic requirements Requirements of building with reference to purpose and function, environment, climate, materials and

methods of construction.

Design Marketing centres, offices, clinics, schools, gymnasiums. Block of flats, offices, educational building, departmental stores, libraries, industrial building, recreation centres, laboratories.

Introduction to energy-efficient design of buildings.

Group B

Social housing Housing in relation to national economy housing policies and programmes of the five-year plans; study of various housing schemes such as low income group housing schemes, slum clearance schemes, etc. Housing design and standards, desirable standards for various income groups, climatic considerations in housing design; land sub-divisions and preparation of housing layouts; study of building rules, regulations, byelaws and codes; plot dimensions and densities.

Based on the above topics, the examination will be held for a period of four hours. The candidate will be expected to produce plans, elevation, section, etc. on drawing paper with sufficient dimensions to explain the scheme. Perspective view and detailing of interesting portion may be added by him. Emphasis of the problems shall be on the arrangements of various functional areas on the basis of data provided. Presentation techniques, analysis of area requirement, climatic considerations and following important building regulations.

Recommended Books

- w C Correa. Complete Works of Charles Correa.
- w Mills. Planning: The Architects' Handbook.
- w A K Jain. Housing For All. (khannabooks.com) Khanna Publishing, Delhi.
- w De-Charia Time Saver Standards for (a) Architectural Design Data, (b) Residential Development, (c) Building Types, and (d) Site Planning.

AR 411

SOIL MECHANICS AND FOUNDATION ENGINEERING

Group A

Soil identification and classification Introduction—soil as a three-phase system. Atterberg's limits and indices; weight-volume relationship; particle size analysis; specific gravity.

Physical and mechanical properties Compaction characteristics; determination of field density; standard and modified Proctor's tests. Permeability and laboratory determination; field pumping tests; effective stress principles; flow nets and their applications. Elements of shear strength; study of laboratory direct shear; unconfined compression and triaxial shear tests. Theory of one-dimensional consolidation; principles of methods of estimation of settlements.

Subsurface investigations Exploratory borings, depth of exploration; spacing and number of boring; methods of sampling and types of samples; bore logs; core recovery; rock

quality designation; field vane shear test; standard penetration test and its applications; field plate load test and limitations.

Group B

Ultimate bearing capacity of shallow foundations Concepts of ultimate bearing capacity; important parameters influencing the ultimate bearing capacity; estimation of safe allowable bearing capacity. Plate load test. Elements of combined and raft foundations.

Deep foundations Classification of piles; bearing capacity of deep foundations; settlement predictions in case of piles in compressible soils. Elements of well foundations. Pile load test and use of relevant BS code.

Improving the soil at site Different methods of improving soil characteristics at site. Elements of soil stabilization, sand drains and vibroflotation techniques. Use of geotextiles.

Recommended Books

- w B C Punmia. Soil Mechanics and Foundations. A Saurabh & Co. (P) Ltd., Chennai.
- w J Jha and S K Sinha. Construction and Foundation Engineering. Khanna Publishers, Delhi.
- w V N S Murthy. Soil Mechanics and Foundation Engineering. Dhanpat Rai & Sons, Delhi.

AR 412

CONSTRUCTION TECHNOLOGY

Group A

Clearing of site, diversion of services, planning and execution of temporary works, provision of infrastructural facilities, line out/ layout of works.

Foundations Open foundations, shoring and strutting, pile foundations, various types of piles such as under reamed, cast-in-situ precast, etc., sheet piles, diaphragm wall, problems in water-logged soil, black cotton soil problems, brick and stone masonry in foundations. Raft foundations, machine foundations, use of bentonite, foundations for timber and steel-framed structures, anti-termite treatment of foundations.

Group B

Load bearing and framed structures Comparison—mode of action, rigid frames, earthquake resistance, timber, steel and RCC frames. Precast columns and beams. Connections. Bye-law requirements. Design of formwork, stationary formwork, sliding and slip forms, materials for economical and reusable forms, material storage practices, design, erection and removal of scaffolding. Structural steel construction—shop fabrication, erection, rivetted and welded connections, fire and corrosion protection. RCC and prestressed concrete construction practices, prefabrication and precasting. Joining, detailing, bar bending, schedule and shop drawings, modular coordination, standardization, manufacture, storage, transportation and

rejection of precast components. Advantages and limitations of ready mixed concrete. Construction equipment—use of tractors, bulldozers, shovels, draglines, cablewarp and belt conveyors; batching plants, transit mixers and agitator trucks used for ready mixed concrete; concrete pumps, grouting pumps, air compressors, welding equipment, cranes, hoists and other lifting devices, vibrators, water pumps, trolleys, etc. Field tests on materials and finished components, quality control techniques.

Recommended Books

- w S K Sharma. Civil Engineering Construction Materials, Khanna Books, Delhi.
- w W C Huntington. Building Construction. Wiley International.
- w P N Khanna. Indian Practical Civil Engineers' Handbook. Engineers' Publishers, Delhi.

AR 413

THEORY OF STRUCTURES

Group A

Slopes and deflections in simply supported beams; double integration and moment area methods. Theorem of moments, fixed and continuous beams. Eccentric loads on short columns. Long columns, secant and empirical formulae. Columns subjected to lateral loads. Basic elastic theorems; Castigliano's, Maxwell's, Betti's theorem and Mueller Breslau's principle.

Group B

Deflection of framed structures. Redundant framed structures. Moving loads on simply supported beams. Influence lines for bending moment and shear force in statically determinate beams and forces in members of framed structures. Moment distribution and slope deflection methods. Kani's methods—application to continuous beams and portals. Arches—3 hinged, 2 hinged and fixed. Suspension bridges with stiffening girders.

Recommended Books

- w S Ramamrutham. Theory of Structures. Dhanpat Rai & Sons, Delhi.
- w S Timoshenko and D H Young. Elements of Structures of Materials. D Van Nostrand Inc.
- w Vazirani and Ratwani. Analysis of Structures. Vols I & II. Khanna Publishers, Delhi.

AR 414

PRESTRESSED AND PRECAST CONCRETE STRUCTURES

Group A

Concrete technology Types of cement, their manufacture, properties of coarse and fine aggregate and their influence on

quality of concrete. Testing method of materials. Grade of concrete; strength requirements and workability methods of selection and proportioning of materials; water cement ratio; introduction to mix design. Destructive and non-destructive methods of testing of concrete. Shrinkage and creep of concrete.

Precast concrete Requirements of industrialised buildings, standardization of precast elements and unification of building design. Influence of manufacture, transport and erection technologies on design solution; expansion and contraction joints. Joints and connections; classification and their requirements. Advantages and disadvantages of precast concrete construction; different types of units involved in general building construction, including residential, factory and industrial framed structure; their general principles of design; mechanical handling of large projects.

Group B

Prestressed concrete Historical development, basic concepts of prestressing, materials used and their properties; methods and systems of prestressing. Losses in prestress. Analysis of sections subjected to prestress and external load; general principles of design; Kern points, cable profile; choice of sections, principal tension; advantages of prestressed concrete over reinforced concrete. Use of prestressed concrete for long span bridges, hangers, auditoria, etc.

Recommended Books

- w S. B. Vanakudre. Prestressed Concrete, khannabooks.com. Khanna Books, New Delhi.
- w C W Glover. Structural Precast Concrete. C R Books Ltd., Delhi.
- w Koncz-Banverlag Manual of Precast Concrete Construction Principles of Roof and Floor Units.

AR 415

STRUCTURAL DESIGN

Group A

BS loading: Dead loads, live loads, wind and earthquake loadings.

Steel design: Rivetted and welded joints subject to direct loads and moments. Tension and compression members. Plate girders, lattice girders. Column subject to axial loads and eccentric loads. Gusseted bases and grillages. Design of trusses, elevated tanks, silos, stacks, building frames, highway bridges. Elementary limit design. BS code of practice for steel structure.

Group B

RCC: Slab—singly, 2-way reinforced and flat. Beams—rectangular, T and doubly reinforced. Adhesion, bond anchorage and shear reinforcement. Axially and eccentrically loaded columns. Footings, single and combined, rafts. Design of retaining walls, building frames, water tanks (underground and elevated), bunkers, silos and highway bridges. Elementary ultimate load theory. Prestressed concrete. Principles and practice of

prestressing. BS code of practice for RCC.

(Use of relevant BS codes and steel tables allowed in the examination hall.)

Recommended Books

- w A S Arya and J L Ajmani. Design of Steel Structures. Nem Chand and Bros (Publishers), Roorkee (UP).
- w S Ramamrutham. Design of Reinforced Concrete Structures. Dhanpat Rai and Sons, Delhi.
- w Bureau of Indian Standards: BIS Handbook for Structural Engineers—Vol I; Structural Steel Section—Vol II; Steel Beams and Plate Girders—Vol III; Steel Columns and Structures. Manak Bhavan, Bahadur Shah Zafar Marg, New Delhi.

AR 421

EKISTICS

Group A

The science of human settlements—subject and its components. Aspects and elements of human settlement. Ekistic units and grid. Study of human settlements—disciplines of human settlements. Methodologies of ekistics.

Perspectives for ekistics Ekistics analysis—anatomy and physiology of human settlements. Rural and urban settlements.

Group B

Ekistic cadution: Evolution of species, growth of settlement, transformation of settlements, ekistics pathology and diagnostics.

Ekistic theory: Principles and laws of ekistics, laws of development, internal balance and physical characteristics, human needs, forces shaping settlements, ekistics synthesis. Ekistics therapy—ekistics goals, new tasks ahead, ekistics practice.

Recommended Books

- w Ekistics—An Introduction to the Science of Human Settlements. Hutchinson & Co., London.
- w Journal on Ekistics. Hutchinson & Co., London.

AR 422

TOWN PLANNING AND LANDSCAPE ARCHITECTURE

Group A

Introduction: Evolution of town planning; aims and objectives of urban and rural planning; study of socioeconomic and demographic characteristics of villages, towns and cities; their present growth trends and future needs; contemporary planning concepts—Goddess, Howard, Dosciadis, Perry and Le Corbusier.

Planning problems Identification of planning problems related to land use, distribution and change; communication system; overcrowding; slums, sporadic growth and conurbation;

development of satellite towns; urban renewal.

Planning surveys: Importance and techniques of planning surveys; sources of information; analysis of data and use of inferences for working out planning proposals.

Planning standards: Formulation of planning standards for land use, density, roads and various community facilities at local and town levels.

Development plan: Planning process; concept of master plan, its elements, preparation and implementation; detailed planning proposals for residential neighbourhood.

Regional planning: Concept of regional planning, types of regions and locational factors of settlements. A critical review of regional theories.

Planning legislation: Review of the development of planning legislations in India, UK and some other countries; detailed study of latest planning of Acts on Housing.

Group B

History and modern trends: Introduction to landscape architecture—its importance for human well-being, Early experiments and development. Integration of buildings and landscape, indoor and outdoor spaces, form, colour and texture.

Landscape planning: Landscape planning of large township and estates. Landscape planning for individual building projects. Landscape planning for public spaces, educational institutions. Site developments by exploiting natural forms. Problems of earthwork, grading of alignments, circulation and utilities.

Plantation: Local plants, materials and adoption for landscaping with reference to behaviours and climate, field identification of a new Indian plants and flowers and study of their ecological characteristics.

Environmental design: Application of principles of architecture and landscape for environmental design of projects.

Recommended Books

- w N K Gandhi. Study of Town and Country Planning in India. Indian Town and Country Planning Association, Mumbai.
- w K Lewis. Principles and Practice of Town and Country Planning. Estate Gazette, London.
- w M Lausie. An Introduction to Landscape Architecture. Pitman, London.
- w A K Jain. Town Planning, khannabooks.com.

AR 423

CLIMATOLOGY

Group A

Effect of climate on men, shelter and environment; conditions for human comfort.

Macro climate and micro climate. Effect of topography on climate. Solar control, standard time, local time, altitude. Declination of sun, sunpath with diagrams. Shading devices for under and overheated periods. Shading effect of trees and vegetation. Use of heliodon and Gunner Pligets sun-dial in the analysis of problems.

Group B

Air flow patterns inside the building. Effect of winds on layouts. Thermal effect on building materials, heat transfer coefficients of different materials. Protective devices for buildings against heavy monsoons. Regional approach of principles of climatology to the design of buildings with respect to site selection.

Town structures, public spaces, orientation, colour positions of windows, types of walls and roofs.

Recommended Books

- w JE Aronin. Climate and Architecture. Reinhold Publishing Corporation, USA.
- w JE Hobbs. Applied Climatology. Butterworths, London.
- w R Geiger. The Climate near the Ground. Harvard University Press, Massachusetts.
- w O H Koenigsberger. Manual of Tropical Housing and Building—Part I, Climatic Design. Longmans.

AR 431

PROFESSIONAL PRACTICE

Group A

Concept of word 'profession'. Difference between profession, business and trade.

Tender documents: Special and general conditions of contract. Types of tenders, their merits and demerits, invitation of tenders, procedure for opening and scrutiny of tenders. Selection and report to client. Contract—legal definition, work order.

Building byelaws: Building rules and regulations applicable to important metropolitan centres, approval of sites—area, height and ventilation for rooms, open space around buildings, height of buildings, parking, structural requirements, etc. Use of National Building Code of BIS.

Easements and covenants and land acquisition: Indian Easement Act. Natural light and easements in respect of air, light, water, etc. Acquisition of loss of easements, Land Acquisition Act, purpose of acquisition, claim report for acquisition, awards and reference to courts. Property extracts, Urban Land Ceiling Act—introduction of main provisions.

Group B

Insurance: Insurance policy, duties of architect, fire loss assessment, insurable value of property, insurance of constructions, insurance of design, worker's compensation.

Arbitration: Introduction—arbitration, arbitrators, umpire, nature of arbitration, conduct, powers and duties of arbitration and umpire. Procedure—procedure for arbitration, preparation and publication of awards, impeachment. Claims—fire insurance and arbitration of insurable value, claims and damages.

Injunctions: Easements and its definition, features of easements, interim, permanent and mandatory injunctions.

Architect's office: Office setup and administration. Filing and recording of drawings. Nature of partnership, registration of firm and dissolution. Procedure and conduct—membership of professional bodies. Architects Registration Act. Code of professional conduct. Code of architectural competition. Architectural services—normal, additional, special and partial. Scale of fee and mode of payment. Claiming of fee. Architects Act of Registration of 1972, copyright of drawings.

Recommended Books

- w Architects Act, 1972.
- w Cinematographic Act, 1952.
- w Development Control Rules & Building Bye-laws as applicable to the States.
- w Indian Arbitration Act, 1940.
- w Easement Act, 1982.
- w Ronald Green. The Architect's Guide to Site Management. The Architectural Press, London.
- w E E Sæbye. Field Practice. Wiley International.

AR 432

MAPPING A THESIS PROJECT

Group A

Designing of one live project: Design of a proposed project. The project should include physical survey of site, analysis and formulation of requirements, climatic study of site, circulation diagram, local architectural history and character, local materials, planning process, structural analysis, quantity surveying and specifications, construction method, landscaping, model.

Group B

Optional services: Sanitation, water supply, sewage disposal, acoustics, air-conditioning, heating, ventilation, fire-fighting, electrical supply.

AR 433

INTERIOR DESIGN

Group A

Free-hand sketching, basic colour chart, analysis and study of colour, study of two-dimensional and three-dimensional forms of plan, section, elevation.

Group B

Furniture study and design, study of building materials, perspectives and rendering. Interior layout, furnishings, presentation of interior design.

AR 433

INTERIOR DESIGN

Group A

Introduction—point plotting, line drawing, raster graphics and vector displays—two-dimensional transformations. Clipping, windowing—graphic input devices and input techniques—graphic packages, segmented display files, geometric models, and picture structures.

Group B

Three-dimensional graphics—curves and surfaces—transformations, perspective—hidden surface elimination—device independent graphic systems.

Recommended Books

- w D F Rogers. Procedural Elements of Computer Graphics. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- w W K Giloi. Interactive Computer Graphics. Prentice-Hall of India (P) Ltd., New Delhi.
- w W M Newman and R F Sproull. Principles of Interactive Computer Graphics. McGraw-Hill Book Company Ltd., New York.

ENVIRONMENTAL ENGINEERING

Environmental engineering evaluates the actions of human on the environment and develops control measures to minimise environmental degradation. It deals with systems and procedures which limit the impairment of the quality of water, air and the land that human beings use. It includes also the means to control radiations, harmful sounds, heat and cold. Human activities produce wastes as vapours, gases, solids, liquids, or energy states which are dispersed in the environment of water, air, or land around them. Such contamination affects all forms of life on earth and disturbs ecology.

Setting Right the Objectives

Environmental protection has three objectives. The first is to protect people from physiological harm from pathogenic organisms, toxic chemicals, and excesses of released energies. The second is to spare human beings, animals and plants from annoyance, irritation and discomfort forced upon by offensive water, air and land. The third objective is to safeguard the balance in the Earth's ecosystems and to conserve natural resources. It is strongly advocated that this last objective should be the primary goal of environmental protection.

Lessons—Nature Taught

When waste materials released in water, air, and land overwhelm the natural process of assimilation of such wastes, pollution occurs. Pollution jeopardizes one or more of the three objectives of environmental protection. If the airborne waste loads are too high, horizontal and vertical air movements cannot disperse them. Additionally, conditions of inversion, stagnation and ultraviolet radiation produce reactants from the primary pollutants. Not all wastes are usable as a food for the natural biota; these are called non-biodegradables. The chlorinated hydrocarbon pesticides are high in the list of contaminants which change slowly in the open environment.

Striking a Balance

To keep ecological balance, the alternatives are to eliminate the source and the waste; to treat the waste to reduce the deleterious load on the open environment; or to augment the environmental capacity to assimilate the waste. All of these are applied in one way or another by the environmental engineer to manage liquid, solid and airborne wastes.

Industrial Policy

Through interdisciplinary environmental teams, industry is directing large amount of capital and technological resources to define and resolve environmental challenges. Each pollution problem has its own unique approach and solution. Restrictive standards stipulate high retention efficiencies for all control equipment. Off-the-shelf items of the past no longer suffice. Controls must now be specifically tailored for each situation. Liquid wastes are generally treated by chemical and/or physical means for the removal of contaminants with the objective that the bulk of the liquid can be recycled. Air or gaseous contaminants are removed by scrubbing, filtration, absorption, adsorption or electrostatic precipitation and the clean gas discharged into the atmosphere. The removed contaminants must be disposed safely and wisely.

Awareness in India

In India, a Committee on Human Environment was set up in 1970 by the Government under the chairmanship of a member of the Planning Commission. At the instance of this Committee, a National Committee on Environmental Planning

and Coordination (NCEPC) was set up in February 1972. Based on its recommendations, the Department of Environment was set up by the Government in 1980 for planning, promotion and co-ordination of environmental programmes. Later, this Department was renamed as Department of Environment, Forests and Wildlife in 1985. The Department deals with environmental policy, law, impact assessment, research promotion, conservation, pollution control, forests and wildlife management and international co-operation.

Legislative Actions

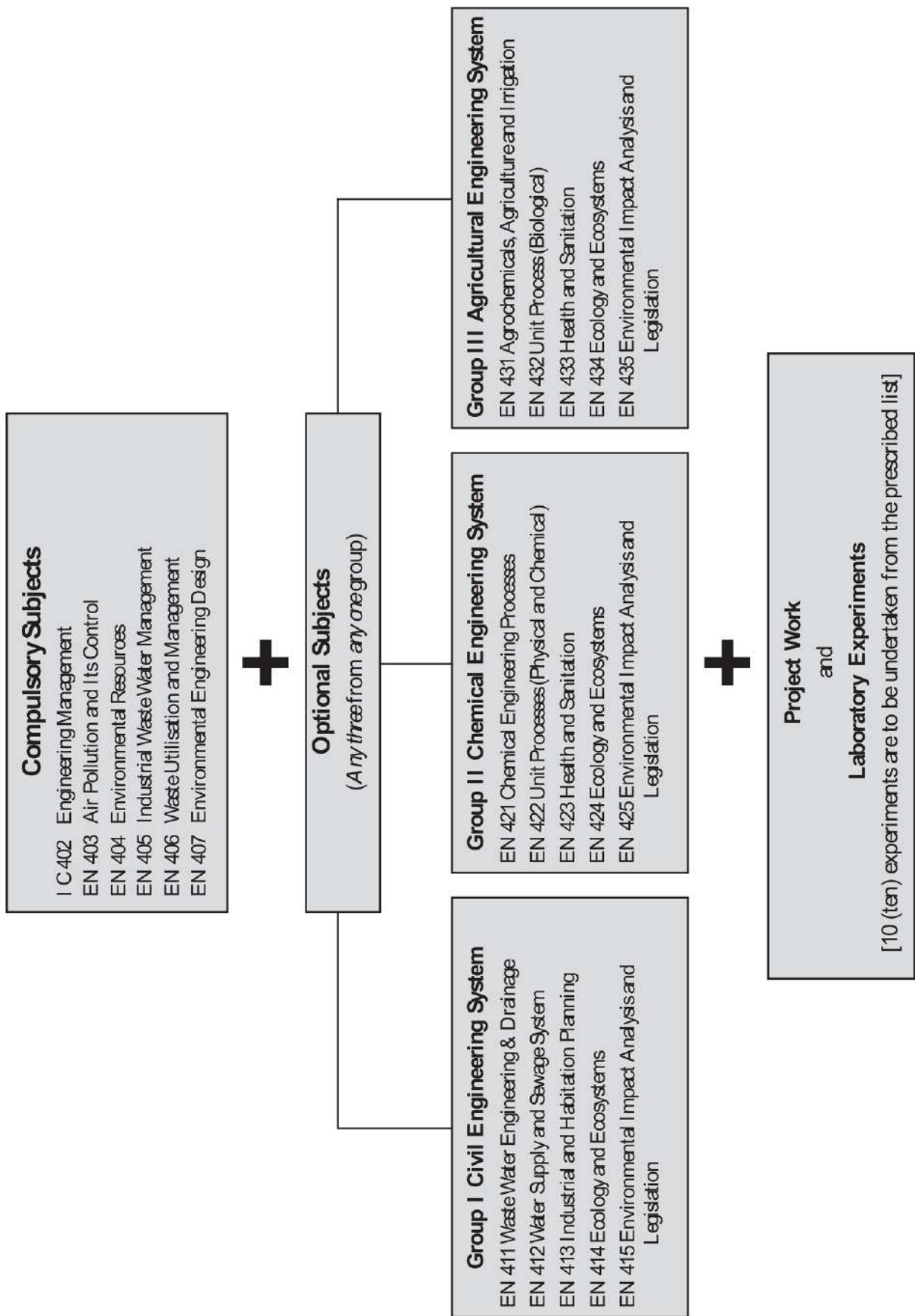
The Air (Prevention and Control of Pollution) Act, 1981; Water (Prevention and Control of Pollution) Act 1974; and the Water Cess Act, 1977 were enacted by the Government. Subsequently, the Ministry of Environment, Forests and Wildlife enacted the stringent Environment (Protection) Act in May 1986. It covers all types of pollution including that by noise.

Some of the national level organisations in the field of environmental engineering are: Central Pollution Control Board; Central Ganga Authority; National Eco-Development Board; National Environmental Engineering Research Institute; and All-India Institute of Hygiene and Public Health. The National Museum of Natural History, set up in 1972, is also promoting nonformal education in the area of ecology, wildlife and environment stressing the responsibility of man in this regard.



Smoke nuisance

ENVIRONMENTAL ENGINEERING



ENVIRONMENTAL ENGINEERING

IC 402

ENGINEERING MANAGEMENT

(See page 13, subject IC 402)

EN 403

AIR POLLUTION AND ITS CONTROL

(See page 24, subject CV 423)

EN 404

ENVIRONMENTAL RESOURCES

Group A

Environmental resources and population: Dimensions of human predicament; the world problematic; essence of the predicament; interactions of resources, economics and politics; interactions of technology environment and well-being; Earth's solid surface and below; hydrosphere, atmosphere and climate.

Human population and food: Population growth, demographic projections and population structure; population distribution and movements; production of food; dimensions of world hunger; distribution of food; undernourishment and malnourishment; expanding the harvest; new and unconventional food sources; renewable resources.

Water: Availability; geographical and temporal distribution; reliability of water resources; ground water; patterns of use and supplies; withdrawal and consumption; irrigation requirements; flow requirements; increasing the supply; water projects; water conservation strategies; problems of water quality on prosperity. Ground water recharge and rainwater harvesting.

Forests: Forests and land resources; world forest reserves; national forest policy; timber industry; unsound practices; pressures on world forests; by-products of forests, forests and industry; social forestry.

Land: Abuse and misuse; vegetation and cultivation; grazing lands; soil erosion and ravines; mining; soils and humus; classification of soils; exhaustion and ecoregeneration; characteristics and potential of soils; reclaiming soils.

Group B

Wildlife: Role of wildlife in environmental conservation; national parks and sanctuaries: Indian scenario.

Energy: Size and sources of contemporary energy use; growth and change in energy flows; supplies, depletion and limits; energy technology; solar energy and its development; prospects and potential of different forms of energy; energy use and conservation.

Non-renewable resources: Use of metals and materials; prospects and problems; augmenting resources; recycling, substitution and low-grade ores.

Resources and environmental disruption: Growth of chemical industries and chemicalisation; chemicals and bioforms; biotransformation; ionising radiations; environmental and health hazards; bioligisation and multinational corporations.

Environmental policies: Population control policies; GNP and quality of life; science and technology, and laws; global commons—tragedy of the commons; feeding the rich and overconsumerism; the poor and the environments; women and nature; transforming nature; improving gross national product; environment and ethics; alternative approaches.

Recommended Books

- w V V N Murthy. Land and Water Management Engineering. Kalyani Publishers, New Delhi.
- w S C Charma. Environmental Engineering. Khanna Book Publishing (P) Ltd., New Delhi.
- w O P Gupta. Elements of Environmental Pollution Control. Khanna Books, New Delhi.

EN 405

INDUSTRIAL WASTE WATER MANAGEMENT

Group A

Quality and quantity of waters for industries: Water consumption as a unit of production and as fraction of the total for the community; criteria formulation for industrial waters; key parameters for different industrial waters with respect to relevant Indian standard specifications; boiler feed waters, cooling water systems; problems of softening; silica scaling and corrosion; caustic embrittlement; internal treatment practices; heat recovery systems; evaporation processes.

Oil pollution: Sources of oil from industries; fats, oil and grease (FOG) removal; oil traps and skimming traps; use of DAF systems; oil spills and oil slicks; control solutions.

Group B

Water pollution & control: Standards prescribed for discharging into various sinks; chemical versus ecological parameters; effluent and environmental (stream) standards; costs of pollution control.

Principles of water pollution control: Reduction of strength and volumes; neutralisation; equalisation; proportioning; processes for removal of various parameters; suitability of control processes compatible with concentrations; environmental industrial location considerations.

Applications: Implant surveys; ascertaining present plant capacity; joint/ combined collection systems including treatment facilities like IPCL, Vadodara.

Effluent channel. Project and NOWED; site selection.

Major industrial wastes: Apparel, food processing, material processing and chemical industries, familiarisation with dominant parameters of pollutants and methods to control them, flow sheets for treatment and disposal of industrial wastes. Common effluent treatment plant.

Recommended Books

- w S C Scharma. Environmental Engineering. khannabooks.com.
- w Metcalf and Eddy. Waste Water Engineering Treatment and Disposal. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- w O P Gupta. Elements of Environmental Pollution Control. Khanna Publishing, New Delhi.

EN 406

WASTE UTILISATION AND MANAGEMENT

Group A

Wastes—consequence of life; impacts of waste generation; public attitude to waste utilisation and recycling; quantities of wastes; challenges and opportunities; historical developments; legislation.

Municipal solid wastes: Sources; types; composition; generation rates; aesthetics and health aspects; onsite storage; processing; collection; analysis, transfer and transport; need for transfer stations; volume reduction; mechanical size reduction; component separating; drying and dewatering; recovery of chemical and biological conversion products; materials and energy recovery systems; flowsheets; disposal sites; landfilling; gas and leachate movement and control; ocean disposal, incineration; pyrolysis.

Hazardous wastes: Identification; classification; generations; regulations; collection, transfer and transport; processing; disposal.

Biomedical waste: Identification, classification, generation, collection, processing, treatment and disposal. Some case studies of biomedical waste, etc.

Group B

Liquid wastes: Recycling of nutrients; reuse of wastewaters; hydroponics; waste utilisation technology in maize products, pharmaceuticals, inorganic chemicals, textiles, pulp and paper, agro industries, electroplating, petrochemicals, refineries and chlor-alkali industries; biomanagement for waste utilisation; recycling of phosphorus, lime, alum and chemicals; solar energy applications in waste utilisation, sewage fed pisciculture; recycling of nutrients of night soil.

Gaseous wastes: Scrubbers; crystallisation; economical aspects of recovery of byproducts or process modification in air pollution control technology; case studies.

Collection of waste: Remedies and its utilisation.

Recommended Books

- w SC Shanna. Environmental Engineering. Khanna Book Publishing, Delhi
- w Handbook of Solid Waste Management.

EN 407

ENVIRONMENTAL ENGINEERING DESIGN

Group A

Water demand: Population forecasting. Determination of water demand, storage capacity of impounding reservoirs. Design of intake works, Jackwell pumps and rising main. Design of infiltration wells and galleries. Design of flocculation basins; Round the end baffle type.

Sedimentation: Design of rectangular and circular settling tanks with inlet, outlet and sludge removal facility. Design of clariflocculator, sludge blanket clarifiers, tube settlers, improvement of existing settling tanks with modified designs.

Filtration: Design and construction of slow, rapid and multimedia filters with details like underdrainage filter media, their preparation and filter washing equipment. Design of inlet and outlet filter piping and rate controllers. Design for miscellaneous processes like taste and odour control, iron and manganese removal, softening plant, demineralization, fluoridation and defluoridation.

Design of water distribution system: Pressure capacity of filtered water pump, capacity of balancing service reservoirs by analytical and graphical methods. Analysis of pipe networks.

Principles of sewage treatment, location of treatment plant. Layout of various units. Hydraulic flow diagram of treatment plant.

Group B

Primary treatment: Design and construction of screen chamber, grit chamber, oil and grease trap, discharge measuring devices; details of mechanical equipment necessary for handling screening, grit, oil and grease trap.

Design and construction of primary settling tanks—inlet, outlet, sludge and scum removal arrangement; sludge pump and pump house. Various types of mechanical scrapers and scum removers.

Biological treatment: Design of activated sludge system; process design; types of processes and modifications; aeration power requirements; types of aerators; diffused and surface aerators; design of aeration tanks and appurtenances; design of trickling filter. Standard and high rate filters. Process design and

design of physical facilities. Design of anaerobic treatment system.

Estimates of sludge quantities in various unit processes; design of sludge pump; design of sludge recirculation system; design of various types of sludge digesters, sludge mixing devices, sludge removal facilities; design of sludge conditioning and thickener units; design of sludge drying beds; process design of vacuum filter; design of equipment details.

Design of tertiary treatment processes—adsorption; ion exchange, pressure filters and modern dissolved solid removal processes. Nitrification and denitrification.

Recommended Books

- w H S Peary and D R Rowe. Environmental Engineering. McGraw-Hill International.
- w RK Linsley and JB Franzini. Water Resource Engineering. McGraw-Hill International.
- w G M Masters. Introduction to Environmental Engineering and Science. Prentice Hall of India (P) Ltd., New Delhi.

EN 411

WASTE WATER ENGINEERING AND DRAINAGE

Group A

Introduction: Definitions of dry and water carriage systems of excreta disposal wastewater, domestic wastewater (domestic sewage), industrial wastewater, stormwater runoff, sanitary waste water, combined wastewater, sewer, sanitary sewer, storm sewer, combined sewer, sewerage, separate and combined systems of sewerage, waste water treatment, wastewater disposal, drainage of buildings systems, piping, fittings.

Collection and transportation of waste water and storm drainage: Estimating design flows through sanitary sewer, storm sewer and combined sewer, sewer geometry and construction materials. Hydraulic design of sewers flowing full and partly, full sewer appurtenances—street inlets, manholes, inverted siphons, sewage pumping stations.

Group B

Waste water characteristics: Kinetics and progression of biochemical oxygen demand (BOD), chemical oxygen demand (COD), solids, nitrogen, phosphorus, potassium, nitrogenous oxygen demand (NOD), toxic metals, other organic and inorganic materials, bacteria and other microorganisms.

Waste water treatment: Concept of wastewater treatment, principles and design of screens, grit chamber with flow control device, sedimentation tanks, and aerobic and anaerobic biological systems, conventional activated sludge, trickling filters, waste stabilization ponds and septic tanks; chlorination of sewage; sludge—types, quantity, treatment and disposal.

Effluent disposal: Disposal by dilution, sewage farming.

Rural sanitation: Low cost toilets—borehole latrines, pit privies, pour-flush toilet.

Recommended Books

- w Metcalf and Eddy. Waste Water Engineering Treatment and Disposal. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- w G M Fair, J C Geyer and D A Okun. Elements of Water Supply and Waste Water Disposal. John Wiley International.
- w Drainage Manual of Water Resources. Oxford & IBH Publishing Co. (P) Ltd., New Delhi.

EN 412

WATER SUPPLY AND SEWAGE SYSTEM

Group A

Sources of water: Surface and subsurface sources, intake water works. Yield test of wells.

Quality of water: Demand of water, variation of demand, design period, design flow of water and waste water.

Pipes and conduits for water transport and house plumbing. Water distribution and sewage system, joints of pipes, corrosion of pipe and joints.

Laying of pipes and sewers and tests for straightness, water tightness, smoke test.

Prevention maintenance; leak detection techniques; nuisance organisms in distribution systems.

Distribution appurtenances; nonreturn, sluice, air and regulating valves; fire hydrants, fountain heads; taps ferrules; pillar cocks, stopcocks; appurtenances for service reservoirs.

Group B

Sewerage appurtenances: Inspection chambers, manholes, flushing tanks, leaping weirs, interception traps, catch pits, manitraps, gully traps.

Service/ distribution reservoirs: Height of service reservoirs, locations and capacity of reservoirs. Pressures of water, remedial measures for boosting pressures of existing system of distribution.

Water pumping stations: Design parameters of wet well and dry well systems, capacities of pumps, standby provisions.

Sewage pumping stations: Nondlog variety of pumps; hydraulic design parameters.

Commissioning of water supply and sewage systems: disinfecting procedures.

Design of soakaway systems: Percolation test; soakaway pits and trenches; radial soakaway systems.

Recommended Books

- w T J McGhee. Water Supply and Sewerage. McGraw-Hill International.
- w G M Fair, J C Geyer and D A Okum. Elements of Water Supply and Waste Water Disposal. John Wiley International.
- w S C Sharma. Environmental Engineering. KhannaBooks.com.

EN 413

INDUSTRIAL AND HABITATION PLANNING

Group A

Planning or laissez-faire: Object and scope of planning: Survey, zoning, accommodation, open spaces and green belts, neighbourhood and community planning.

Planning Bye-Laws: Setback and margins, floor space index.

Planning: Aspect, prospect, furniture requirements, roominess, grouping, circulation, privacy sanitation and elegance.

Buildings: Residential, public and industrial buildings.

Group B

Siting of industries in general and hazardous industry in particular, provision of fire safety and other safety precautions. Environmental guidelines for siting an industry. Planning and drawing of small residential and industrial units; structures of industrial sheds; trusses and girders.

Typical layout plan of an industrial township.

Ergonomics and its relevance in planning.

Ventilation in industrial building. Guidelines and design of ventilation system in industrial buildings.

Recommended Books

- w Industrial Safety. S C Sharma (khannaBooks.com)
- w Understanding Human Engineering and Introduction to Ergonomics.
- w Shah and Kate Building Drawing.

EN 414

ECOLOGY AND ECOSYSTEMS

Group A

Ecology: Definition and its relation to other sciences and its relevance to human civilization. Subdivisions of ecology.

Concept of ecosystems: The biological control of chemical environment. Production and decomposition in nature. Homeostasis of the ecosystem.

Principles and concepts pertaining to energy in ecological system: Fundamental concepts related to energy, the energy

environment, concept of productivity, food chains, food webs and trophic levels, metabolism and size of individuals, trophic structure and ecological pyramids.

Bio-geochemical cycles: Statement, nitrogen cycle, phosphorus cycle, sulphur cycle, limiting factors-Liebig's law of the minimum, Shelford's law of tolerance, combined concept of limiting factors, ecological indicators.

Biotic community concept: Intercommunity classification and concept of ecological dominance, community analysis, species diversity in community. Pattern in communities.

Species and individual in the ecosystem: Concepts of habitat and ecological equivalents.

Group B

Development and evolution of the ecosystem: The strategy of ecosystem development, concept of the climax, relevance of ecosystem development theory to human ecology, evolution of the ecosystem, co-evolution, group selection.

Rudiments of the systems approach and mathematical models in ecology. Freshwater ecology: Freshwater environment types and limiting factors, ecological classification of freshwater organisms, the freshwater biota (flora and fauna), lentic communities, lakes, ponds, lotic (running water) communities, longitudinal zonation in streams.

Marine ecology: The marine environment and marine biota, zonation in the sea, quantitative study of plankton, communities of the marine environment.

Estuarine ecology: Definition and types, biota and productivity, food production potential.

Terrestrial ecology: The terrestrial environment, the terrestrial biota and biogeographic regions, general structure of terrestrial communities, the soil subsystem, the vegetation subsystem. The permanence of the terrestrial environment, distribution of major terrestrial communities, the biomass.

Recommended Book

- w J L Chapman and M J Reiss. Ecology: Principles and Applications. Cambridge University Press, UK.

EN 415

ENVIRONMENTAL IMPACT ANALYSIS AND LEGISLATION

Group A

Status of India's environment: Need and greed; biomass oriented eco-development; qualitative and quantitative aspects of India's environment with respect to people, land, forests, water, air, wildlife, energy, mineral resources, etc; patterns of change; causes of change.

Scenario of natural property and prosperity; industrial and economic growth.

Constituents of an environmental impact statement: Essential components; alternatives of proposed actions; full disclosure and public comment; assessment methodology; development versus environmental preservation; project assessors; generation of employment potential; cost benefit ratios.

Case studies on impacts of dams, petrochemicals, fertiliser, cements, and pesticide units.

Group B

Environmental Acts: Water Act, Cess Act and Air Act. Environmental Protection Act (EPA). Familiarisation with important sections and clauses. Limitations and lacuna.

General: Role of courts as appellate authorities; need for environmental protection courts as special courts; case studies; importance of consent, NOC and non agricultural application forms; role of voluntary agencies as campaigners and crusaders.

Recommended Books

- w L W Canter. Environmental Impact Assessment. McGraw-Hill International.
- w R E Munn. Environmental Impact Assessment. John Wiley International.

EN 421

CHEMICAL ENGINEERING PROCESSES

Group A

Nitration: Introduction, nitrating agents, aromatic nitration, mixed acid for nitrations, manufacturing of nitrobenzene, O and P chloronitrobenzene, nitronaphthalene and preparation of nitroparaffins.

Sulfonation: Introduction, sulfonating agents and their principal applications, chemical and physical factors in sulfonation, technical preparation of sulfonates and sulphates.

Halogenation: Introduction, various halogenating agents, types of halogenations. Technical preparation of halogenation.

Group B

Absorption: Absorption of gases by moving drops, Henry's law and diffusion inside the drop, material balances for one component system, types of absorption, design concepts for absorption tower.

Adsorption: Principles of adsorption, fixed-bed adsorbers. Moving-bed adsorbers, design concepts for absorption tower.

Liquid extraction: Liquid equilibria, equipment and flow sheets, stage-wise contact, stage-type extractors, continuous-contact extractors.

Recommended Books

- w P H Groggins. Unit Processes in Organic Synthesis.
- w R E Treybal. Mass Transfer Operations. McGraw-Hill International.

- w Gupta. Air Pollution Control Engineering. khannabooks.
- w J M Coulson and J F Richardson. Chemical Engineering. Pergamon Press, Oxford.

EN 422

UNIT PROCESSES (PHYSICAL & CHEMICAL)

Group A

Introduction: Characteristics of water, wastewater, air/ gas, soil, food; parameters for quantifying quality requirements, criteria, standards and their evolution; basis of permissible limits; interpretation of analysis report of water, wastewater, sludge, soil and gas/ air.

Quantities of water: Wastewater and gas flows; water requirements for domestic and industrial purposes; wastewater formation; estimation of air requirements for compressors; estimation of flue gas flows; spectrum of particle size distributions; variations in flows and particle sizes.

Theory of discrete settling: Stoke's law applied to fluids; design concepts for settling chambers and cyclones; efficiency of sedimentation units; types of sedimentation tank; control of quiescent flow.

Coagulation flocculation: Colloids and their stability, mechanisms of destabilisation; limitations; mechanical and hydraulic flocculation; coagulating agents and their recycling.

Flow through porous media: Mechanisms of filtration; dominant mechanism for a particular size; hydraulics of filtration; filter logging; filter washing; types of filters and their flow directions, breakthrough.

Group B

Softening: Chemical precipitation, softening; preparation of bar charts; estimation of doses of chemicals; ion exchange mechanism and Kunin's laws; mass balance.

Desalination: Methods of removal of dissolved solids; solar distillation gadgets and plants; multistage flash distillation; vapour compression; direct freezing; reverse osmosis; electrodialysis; estimation of energy costs.

Physico-chemical removal of dissolved organics; separation mechanisms and isotherms; estimation of sorbent requirements; form separation of sorbent requirements; form separation; liquid-liquid extraction; removal of iron, manganese, fluorides and colour.

Disinfection: Chick's laws of disinfection; phenol coefficient; disinfection practices; use of chlorine, ozone and other disinfection.

Sludge dewatering and disposal: Sources of sludge; estimation of bulk density of sludges; principles of dewatering; estimation of rate of filtration; methods of dewatering and their suitability; thickening; chemical conditioning; elutriation; vacuum and pressure filtration.

Recommended Books

- w S C Sharma. Environmental Engineering. Khannabooks.com.
- w A Dasgupta and N L Nem. Industrial and Hazardous Waste Treatments. Van Nostrand Reinhold, New York.

IC 402

ENGINEERING MANAGEMENT

Group A

Introduction: Hygiene—health, positive health illness, diseases. Importance of air, water, food and daily industrial activities, principles of health education.

Water: Importance of water, sources of water. Evaluation of different sources in terms of quantity, quality and hygiene, water-borne diseases.

Environmental planning: Importance of environmental planning and health—lighting, its types and uses. Artificial cooling/heating—minimum floor area and cubic space—air and ventilation; lighting of an inhabited area/ room.

Rural sanitation: Definition related to sanitation. Inventory of resources in rural areas and appropriate technology. Collection and removal of refuse; human excreta—conservancy system. Different types of latrines and low cost sanitation methods. Biogas technology and its design—smokeless chullahs and advantages.

Food and nutrition: Importance of food, constituents of food. Classification of foods—metabolism and diet requirements. Food calorie—scale of average caloric requirements in India, balanced diet, composition of well balanced diet, calorific value of important foods per gram, composition of principal foods in grams per ounce diet for pregnant and lactating mothers, diet for infants and children; faults of Indian diets, nutritional surveys.

Survey—digestion of food conditions regarding diet to maintain health. Diseases caused by faulty dieting and deficiency diseases. Cooking of food; effects of cooking, different methods of cooking, food poisoning. Preventive measures, vegetable foods, animal foods; chief signs of illness in animals; diseased meat; preservation of meat; tinned meat and fish. Milk—methods of preservation of milk; diseases conveyed by milk-derived milk-cream, butter, cheese, dahi, margarine, ghee, mustard oil, vanaspati, beverages. Fruit drinks—condiments, aromatics.

Group B

Offensive trades and occupational poisoning: Introduction to different terms and offensive industries—occupation, industrial hygiene, ergonomics and its parameters, occupational health, occupational environment and operative agent, namely, physical, chemical and biological; minimum thirteen different

offensive trades and their know-how, appreciation of problems arising from man and man; man and machine interrelationships. Elaboration of physical, chemical and biological agents; occupational poisoning due to metals and its fumes and dusts—lead, mercury, etc; occupational poisoning due to gases and fumes—entry; symptoms and control measures; labour welfare laws and legislation.

Infection and carriers of infection—prevention and control: contamination; epidemiological and environmental aspects. Immunity and its types.

Common preventable diseases: Causes and their prevention.

Personal and mental hygiene: General understanding, types of mental disorders—causes and prevention, promotion of mental health.

Health statistics: Definitions, importance and sources. Health statistics of India and assessment of significance and its tests.

Recommended Books

- w E W Steel. Municipal and Rural Sanitation. McGraw-Hill International.
- w M P Poonia. Engineering Management. khannabooks.com

EN 424

ECOLOGY AND ECOSYSTEMS

(See page 138, subject EN 414)

EN 425

ENVIRONMENTAL IMPACT ANALYSIS AND LEGISLATION

(See page 138, subject EN 415)

EN 431

AGROCHEMICALS, AGRICULTURE AND IRRIGATION

Group A

Agrochemicals

Plant nutrition: Soil properties and applications of fertilizers; chemical amelioration techniques, application of lime and gypsum; nitrogen, phosphorus and potassium fertilizers; micro-fertilizers and compound fertilizers, manure, peat and organic peat fertilizers, green manure, fertilizer system, effect of fertilizer on crop composition and quality, field and green house experiments in agriculture chemistry.

Pesticides, herbicides, fungicides and rodenticides, doses and methods of applications; use of growth factors for higher yields and planned timing for harvest; high density plantation.

Agriculture

Aeroponics, aquaponics and tuboponics, crops raised by saline/ seawater; agroforestry for energy and pollution abatement.

Group B

Irrigation

Irrigation: Necessity, scope and benefits of irrigation, scope and development of irrigation in India. Flow and lift irrigation, its advantages and disadvantages.

Soil and water: Characteristics of agricultural soils; qualities of agricultural water, water requirement for different crops.

Canals: Canal network, classifications of canals, preventive measures of transit losses; canal lining, outlets.

Application of water: Methods of applying water for irrigation, conservative and conjugative use of surface and subsurface water. Wells, yields of wells, tests to determine yields, waterlogging; causes and remedies.

Cost of irrigation: General idea of cost of irrigation by flow and lift system. Environmental impacts of irrigation.

Recommended Books

- w A M Michael. Irrigation Theory and Practice. Vikas Publishing House, New Delhi.
- w B C Mal. Introduction to Soil and Water Conservation Engineering. Kalyani Publishers, New Delhi.
- w N C Brady. Nature and Properties of Soil. ELBS Publication.
- w SL Tisdale, W L Nelson and JD Beaton. Soil Fertility and Fertilizer. Macmillan International.

EN 424

ECOLOGY AND ECOSYSTEMS

Group A

Biological parameters: Biological methods of analysis, parameters affecting BOD; BOD equation; methods of estimating BOD, COD procedures; biological versus physico-chemical analysis.

Water pollution: River, estuarine and coastal pollution; dilutions and dispersions; mass transfer equations; use of error functions; natural purification; estimation of reoxygenation constants; surveillance programmes.

Treatment kinetics: Zero, first, second, fractional and consecutive order reactions in biological treatment; time and temperature effects; recirculations; molecular diffusion; Black and Phelps series.

Biochemical concepts: Chemistry of carbohydrates, lipids, proteins, fats and nucleic acids, enzymes and inhibitions, photosynthesis and symbiosis; enzyme kinetics.

Group B

Reactor design: Biology and energy chain, kinetics of oxic treatment; CSTR and plug flow reactors; mathematical models for fixed film and suspended growth reactors; oxygen requirements; nutrition and sludge age, evolution of treatment systems and modifications; shock loading.

Microbiology and biochemistry of anoxic process: Substrate inhibition; optimal anoxic environment; kinetic constants; stuck reactors; problems; high rate and multistage anoxic digestors.

Low cost systems: UNOX system; cavitator process; oxidation carousel system; biodisc and lagoons; land treatment systems; evapotranspiration and sewage sickness; salvaging nutrients, reuse, recycling and renovation systems.

Refractory removal; N-P control; limitations of biological process; AWF systems and practices; plant performance indices; bulking and rising sludge; shock loading; biodeterioration.

Recommended Books

- w Metcalf and Eddy. Waste Water Engineering Treatment and Disposal. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
- w S C Sharma. Environmental Engineering. Khanna Books, New Delhi.
- w M J Hammer and M J Hammer (Jr.). Water and Waste Water Technology. Prentice-Hall of India (P) Ltd., New Delhi.

EN 433

HEALTH AND SANITATION

(See page 140, subject EN 423)

EN 434

ECOLOGY AND ECOSYSTEMS

(See page 138, subject EN 414)

EN 435

ENVIRONMENTAL IMPACT ANALYSIS AND LEGISLATION

(See page 138, subject EN 415)

Early Voyages

Water transport was of greater importance than communication by roads in ancient times. After 3000 BC, sailing ships of considerable size were evolved. Phoenicians established a trading network in the Mediterranean. Indians established links with various countries in the south-east Asia by sea routes. The Navy used to receive importance in all coastal countries but it received further impetus after the creation of a professional British Navy by Henry VIII and exploration of new lands by Spain and Portugal. R. Volturio gave illustration of boats (1483) with crank driven paddle wheels. Paddle wheel propulsion can also be seen in the paintings of Raphael.

Shipbuilding and marine engineering got a big boost with the production of iron and steel and invention of the steam engine. Jonathan Bull patented a steam boat in 1737. From 1807, regular service with steam ships started.

Brunel, Napier, David and Robert are regarded as founder fathers of marine engineering. Brunel was the pioneer to use screw propulsion. The East India Company stimulated the growth of shipbuilding industry further. The steam turbine was installed in a ship in 1897 leading to more speed and economy. The diesel engine, modern turbines, radio communication, satellite navigation, nuclear power, computer control, etc. have been progressively introduced in marine engineering as innovative steps.

Ship Design

The design of a ship involves a selection of form, size proportions, and other factors. As cargoes and ships have increased in size and complexity, design is more detailed and varied. Intensive research has brought about many technical

Marine Engineering is the discipline concerned with the design and manufacture of ships. It is closely related to naval architecture. In design, the marine engineering is responsible for the selection of the main propulsion plant and all its auxiliaries. These include steam turbines, boilers, diesel engines, gas turbines, or other alternative combinations like nuclear fueled engines for driving the propellers. The electrical plant also comes under its purview, as well as fuel systems, piping and pumps, the refrigeration and air conditioning systems.

The marine engineer plans the machinery layout, does the heat balance and other calculations and, in essence, designs the whole propulsion system. The design of the propeller is, however, sometimes done by the naval architect or some other specialist.

advances in the design and fabrication of ships. These include new welding techniques, developments in propulsion plants, advances in electronics, and changes in materials and methods of construction.

Shipbuilding

This involves the construction of large vessels which travel overseas, lakes or rivers. Many different approaches have been used in the construction of ships. Sometimes a ship must be custom-built to suit specific requirements with unique cargo characteristics. On the other hand,

there are instances where a number of similar ships of the same class is constructed, providing advantage of economy through repetitive processes.

Shipbuilding comprises seven phases: design, construction planning, work prior to keel laying, ship erection, launching, final outfitting, and sea trials. The arduous environment poses critical demands on marine machinery. These include an extra measure of reliability, successful performance on a rolling, pitching and vibrating platform, restrictions on space and weight, as well as corrosion-resistant properties. The purposes served by different types of ships call for design of machinery having specific characteristics.

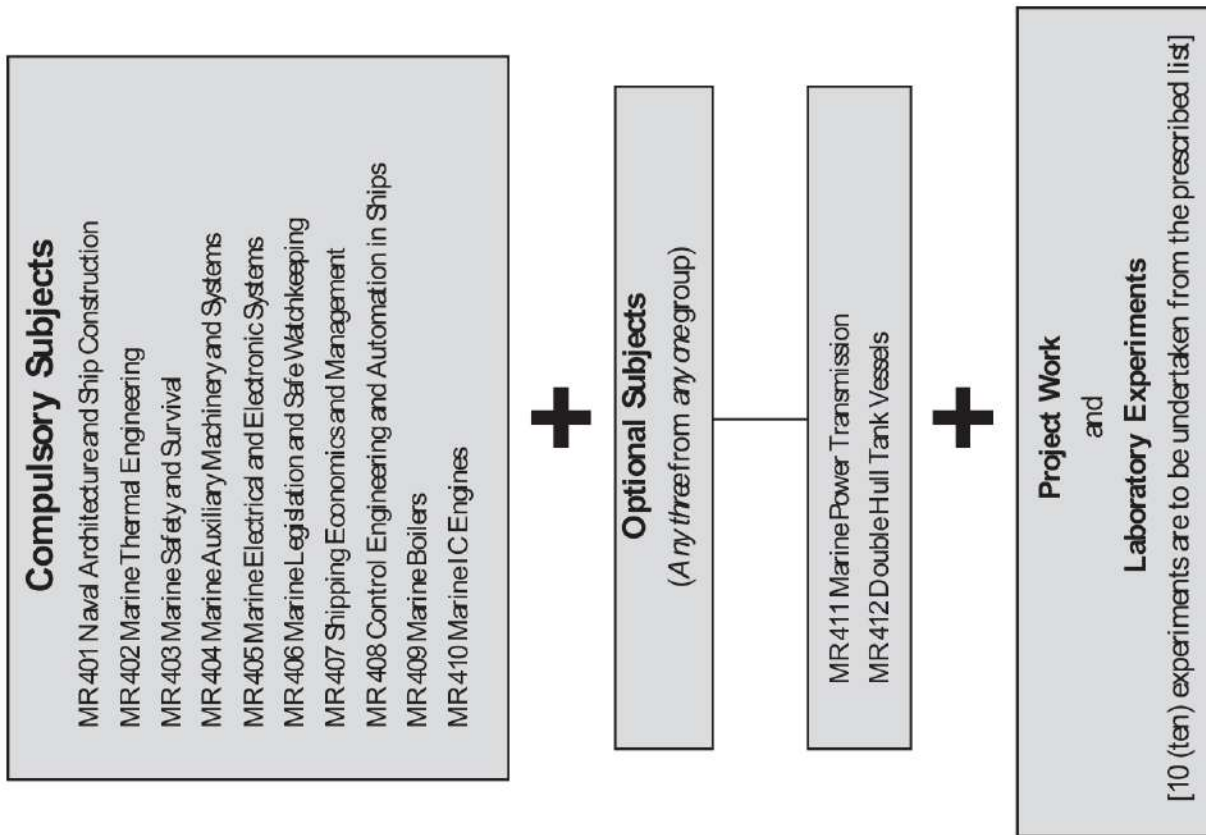
Indian Perspective

The Mercantile Marine Department administers shipping laws. Modern ship building started in India in 1919. India now has a fleet of ships under various shipping companies and the Indian Navy. A number of institutes, including some under the Indian Navy, conduct special courses in marine engineering.



An ocean liner

MARINE ENGINEERING



NAVAL ARCHITECTURE AND SHIP CONSTRUCTION

Group A

Geometry of ship and hydrostatic calculations: Ship lines, displacement calculations, first and second moment of area, Simpson's rules, application to area and volume, trapezoidal rule, mean and mid-ordinate rule, Tehebycheff's rule and their applications, tonnes per cm immersion, coefficients of form, wetted surface area, similar figures, centre of gravity, effect of addition and removal of masses, effect of suspended mass on ship's centre of gravity. Calculation of centre of buoyancy.

Transverse stability of ships: Static stability at small angles of heel, calculation of BM, calculations of transverse metacentric radius BM_T and transverse metacentric height GM_T , including experiment, free surface effect, stability at large angles of heel, curves of static stability, dynamical stability, angle of loll, stability of wall sided ship, IMO stability criteria and stability information booklet, stability in damaged condition.

Resistance and powering: Frictional, residuary and total resistance, Froude's law of comparison, effective power calculations, ship's co-relation factor (SCF), admiralty coefficient, fuel coefficient and fuel consumption, effect of viscosity and application of ITTC and ATTC formulae. Boundary layer, Reynold's number and Froude's number. Effect of shallow/restricted water on resistance, draft and trim of ship.

Longitudinal stability and trim: Longitudinal metacentric radius BM_L , moment to change trim one cm, change of trim, change of LCB with change of trim, change of trim due to adding or deducting weights, alteration of draft due to change in density, flooding calculations, floodable length curves, MOT method for determination of floodable lengths, factors of subdivision, loss of stability due to grounding, docking stability, pressure on chocks.

Group B

Strength of ships: Longitudinal strength, ship hull as a girder poised on waves, longitudinal distributions of weight and buoyancy, weight curve, buoyancy curve, load curve, shear force and bending moment curves, deflection, still water bending moment, wave bending moment, calculation of moment of inertia and section modulus of hull girder, calculation of shear stress and bending stress at any section of the hull girder. Transverse strength.

Propulsion and propellers: Types of propellers—screw propellers (fixed pitch, controllable pitch, diverted, rudder

propellers), vertical axis propellers (Voith Schneider), screw propeller geometry—diameter, pitch, pitch ratio, blade area ratio, rake, skew, pitch distribution, propeller drawing, propeller materials and manufacture. Hullpropeller interaction—wake, wake fraction, augment of resistance and thrust deduction, thrust deduction fraction, propeller slip and slip ratios, real and apparent slip ratios.

Power and efficiency: Thrust and torque, indicated power, brake power, shaft power, delivered power, thrust power, effective power, shaft efficiency (transmission efficiency), propeller open water efficiency, propeller efficiency in behind condition, relative rotative efficiency, hull efficiency, quasi-propulsive coefficient (QPC).

Propeller theories: Momentum theory and blade element theory, cavitation and its effects, ways of reducing cavitation, super cavitating propellers. Propeller model tests and laws of similitude, advance coefficient, J , thrust coefficient K_T and torque coefficient K_Q , ship-model correlation, ship trials.

Rudder theory: Action of rudder in turning a ship, types of rudders, stern rudders and bow rudders.

Geometry of rudder—span, chord, rudder area, aspect ratio, taper ratio, thickness, chord ratio, rudder sections, rudder shapes. Force on rudder, centre of pressure, torque and bending moment on rudder stock, effect of rudder stock, location on torque, balanced, semi-balanced and unbalanced rudders.

Rudder material and construction—rudder stock, tiller, steering gear fundamentals, rudder model tests, ship turning trials, angle of head while turning, precautions to be taken by helmsman, ship maneuvering simulator.

Motion of ship in waves: Theory of water waves, trochoidal waves, sinusoidal waves, wave amplitude, wave height, wave length, wave frequency and time period, wave celerity, wave energy. Motion of water particles in a wave. Irregular sea, wave spectra, sea states, beauforte scale. Ship motions—degree of freedom, surge, sway, heave, roll, pitch, yaw, forces due to these motions. Anti-roll devices—active and passive roll stabilisers, seakeeping—roll, pitch and heave motions in waves, forces due to these motions.

Recommended Books

- R Munro and Smith. Naval Architecture and Ship Construction. I Mar E, London.
- W Muckle. Naval Architecture. Newnes-Butterworth, UK.
- D A Taylor. Merchant Ship Construction. Butterworths, UK.
- Naval Architecture. RINA Publication, DFUK.
- D J Eyres. Ship Construction. Newnes-Butterworth, UK.

MARINE THERMAL ENGINEERING

Group A

Transmission of heat: Application of heat transfer in marine heat exchangers like coolers, heaters and condensers. Prediction of convection heat transfer rates, use of non-dimensional groups.

Prandtl number, Reynolds number, Stanton number, Graetz number, etc. Natural and forced convection.

Marine steam turbines: Developments in steam engines, reciprocating engines to low pressure steam turbines and to modern high superheat, reheat and regenerative plants, general principles of construction and design. Simple impulse, pressure compounded impulse, pressure-velocity compounded impulse. Parson's axial flow reaction turbine, double flow turbine, radial flow reaction turbine, double casing turbine.

General layout and description of a modern geared steam turbine installation including auxiliaries in marine use. Combined gas turbine and steam turbine circuits, location of gears, flexible couplings and thrust blocks, steam, exhaust and drain line system, gland steam system.

Materials used for various components like blades, rotors, gears, casing sealing glands, etc and their jurisdiction.

Lubrication of turbines. Suitable oils and their properties. Film lubrication, forced lubrication, lubrication of main bearings and gears. Types of oil jets, emergency lubrication arrangements.

Operation and maintenance. Warming up procedure for main propulsion turbines, ahead and astern running. Control of power and speed of propulsion. Throttle valve and nozzle control governing, self-closing emergency stop valve, emergency governors, condenser vacuum control, servomotor governors for generators, quick engaging turning gear for turbines.

Group B

Gas turbine plants: Constant volume or explosion cycle gas turbine plant, constant pressure cycle or Joule-Brayton cycle gas turbine plant for simple C-B-T cycle, condition for maximum work output and thermal efficiency in simple cycle. Methods of improvement of thermal efficiency and work ratio of gas turbine plants, C-B-T-H cycle, complex cycles, close cycle operation of turbine plants, its merits and demerits. Total head or stagnation conditions.

Axial flow compressor: Principles of centrifugal compression and pressure rise in centrifugal compressor, change in angular momentum. Pre-whirl and pre-whirl vanes. Mach number at inlet to a centrifugal compressor, slip and slip factor. Multi-stage centrifugal compressor.

Marine refrigerating and AC plants: Typical marine refrigerating plants with multiple compression and evaporation

system, heat pump cycles, refrigeration in liquefied gas carriers. Applied problems.

Principles of air-conditioning, psychometric properties of air, comfort conditions, control of humidity, airflow and AC capacity, calculations for ship plants.

Recommended Books

- G F C Rogers and Y R Mayhew. Engineering Thermodynamics: Work and Heat Transfer. ELBS Publication.
- T D Eastop and A Mckonky. Applied Thermodynamics for Engineering Technologists Longman.
- Rayner Joel. Applied Thermodynamics. ELBS Publication.

MARINE SAFETY AND SURVIVAL

Group A

Deck equipment: Mooring and anchoring—winches, windless, gypsy, capstan, bollards, fairleads. Cargo handling and cargo access equipment derricks, cranes, hatches and hatch covers.

Navigational lights and signals: Forward and craft mast headlights, side lights, NVE light, towing light, fishing lights, etc., colours and locations of navigation lights, shapes, morse and semaphore signalling, sound signals, flags, flag etiquette, look out and precautions in bad weather.

Life boats and life rafts: Construction, equipment carried, carrying capacity. Davits and their operation, launching of life rafts (inflatable type), embarkation into life boat and life raft, survival pack, storage and securing arrangements.

Abandon ship: Manning of life boat and life raft, muster list, radio and alarm signals, distress signal (SOS), distress calls time and radio frequency, pyrotechnics.

Survival at sea: Survival difficulties and factors, equipment available, duties of crew members, initial action on boarding, maintaining the craft.

Practicals: Knots, bends and hitches, rope splice, donning of life jackets, life boat drills. Lowering and hoisting of life boats (model).

MARPOL: Convention and its annexes, regulatory control towards environment, pollution at sea.

Fire hazard aboard ships: Fire triangle, spontaneous combustion. Limit of inflammability, advantages of various fire extinguishing agents, including vaporizing fluids and their suitability for ship's use. Control of class A, B and C fires.

Structural arrangement for different types of ships like container ships, bulk carriers, tankers, Ro-Ro ship, offshore supply/ support vessels, etc.

Group B

Fire protection built on ships: SOLAS convention, requirements in respect of materials of construction and design of ships, fire detection and extinction systems, escape means, electrical installations, ventilation system and venting system for tankers. Statutory requirements for firefighting systems and equipment on different vessels.

Detection and safety systems: Fire safety precautions on cargo ships and tankers during working. Types of detectors and detection system. Description of various systems fitted on ships.

Fire fighting equipment: Fire pumps, hydrants, hoses, couplings, nozzles and international shore connection. Construction, operation and merits of different kinds of portable, non-portable and fixed fire extinguishers for ships. Properties of chemicals used, bulk carbon dioxide and inert gas systems. Fireman's outfit, its use and care. Maintenance, testing and recharging of appliances, preparations for fire appliances survey.

Fire control: Action required and practical techniques adopted for extinguishing fire in accommodation, machinery spaces, boiler rooms, cargo holds, galley, etc. Fire-fighting in port and dry dock. Procedure for re-entry after putting off fire, rescue operations from affected compartments. First aid and fire organisation on ship. Fire signal and muster. Fire drill. Leadership and duties.

Recommended Books

- Reference Publications from IMO for SOLAS and MARPOL. Reprinted by Bhandarkar Publications, Mumbai.
- Fire Fighting and Safe Working. Bhandarkar Publications, Mumbai.

MR 404

MARINE AUXILIARY MACHINERY AND SYSTEMS

Group A

Shafting: Methods of shaft alignment, constructional details and working of thrust blocks. Intermediate shaft bearing and stern tube bearing. Oil water lubricated stern tubes. Sealing glands. Stresses in tail end, intermediate and thrust shafts. Dry docking: Methods of dry docking of ships. Inspection and routing overhauling of underwater fittings and hull. Measurement of clearances and drops. Removal and fitting of propellers.

Other shipboard equipment: Incinerators, sewage treatment plant, engine room crane. Chain blocks, tackles, anchor chain, its testing and survey requirements. Different types of ship stabilizer. Bow thrusters, hull protection arrangements.

Marine refrigeration and air-conditioning plants: Design and constructional details of various equipment for refrigeration and air-conditioning. Refrigerators used in marine practice and

their justification, control of temperature in various rooms in cargo or domestic plants.

Control of humidity in AC plants. Operation and maintenance of plants. Control and safety equipment.

Engine room layout: Layout of main and auxiliary machinery in engine rooms in different ships. Piping arrangement for steam, bilge, ballast and oil fuel systems, lube oil and cooling system lines with various fittings, domestic fresh water and seawater and seawater hydrophore system.

Group B

Pumps: Types of pumps for various requirements, their characteristics and application in ships. Centrifugal pumps, gear pumps, screw pumps and reciprocating pumps. Care and maintenance of pumps.

Evaporators: Construction and operation of different types of evaporators. Freshwater generators and distillers. Conditioning arrangements of distilled water for drinking purpose. Care maintenance of pumps of various types.

Pollution prevention: Oily bilge separators and their construction and operation, use of coalescers, prevention of oil pollution and various international requirements (MARPOL Act).

Deck machinery: Various types of deck machinery used in ships, e.g., winches and windlass, their requirements. Operation and maintenance. Deck cranes.

Oil purification: Theory of oil purification. Principles of operation and construction of different centrifuges for heavy fuel and lubricating oil.

Blowers and compressors: Operational and constructional details of blowers and compressors used on board ships. Uses of compressed air.

Steering gears: Operation and constructional details of various types of steering machinery. Telemotor systems, transmitters and receivers, variable delivery pumps used in steering gears, axial and radial displacement types. Hunting action of steering gear. Emergency steering arrangement. Care and maintenance of steering gear plants.

Recommended Books

- H D McGeorge. Marine Auxiliary Machinery. Butterworth Heinemann.
- Smith. Marine Auxiliary Machinery. Butterworth Heinemann.
- L Jackson and T D Morton. Reeds Vol. 8. Reeds Publications UK.

MR 405

MARINE ELECTRICAL AND ELECTRONIC SYSTEMS

Group A

Starters for miscellaneous electrical equipment for machinery

space auxiliaries and centralized control of motors in machinery space, e.g., sequential starting and cutouts for an automatic fired boiler incorporating safety devices and combustion control equipment. Sequential starting for refrigerating plants, incorporating safety devices like high-pressure cutout, cooling water failure cutout, automatic defrosting with the help of timer. Special requirements of motors and starters for anchor windless and capstan, wiring diagram, lowering and hoisting arrangements, overload protection, magnetic disk, brakes.

Essential equipment and special circuits: Classification of society's requirements for electrical equipment for steering gears, electrical control from wheel house for electrohydraulic steering gear, all electrical steering gear circuit and control equipment, navigation lights.

Miscellaneous marine equipment and alarm system: electrical engine room telegraph, remote indicating revolution counter, remote helm indicator, salinity indicators, mist detectors, carbon di-oxide recorder, electrical equipment for water-tight door operation, centralized alarm system in machinery space for the above, fire alarm system for engine room, holds and accommodation, high temperature alarms, low and high level alarm.

Electric propulsion systems, differences and relative merits, alternating current, diesel electric and turbo electric propulsion system engines, generators, motors, excitation system and control.

Group B

Maintenance of electrical equipment, detection of faults and repairs, preventive maintenance and periodic survey of equipment, classification of society's equipment for spares on board.

Power generation and distribution: Selection of dc and ac generators for use on ships with reference to its prime mover, merits and demerits of ac and dc on ships. Rules and regulations governing electrical machinery on ships, location and installation of generator sets. Rating and characteristics of main switch boards. Arrangements of preferential trips and protective devices with wiring diagrams. Construction and characteristics of brushless high speed ac generators with automatic voltage regulator of magnetic amplifier type. Rapid voltage response of ac generators. AC distribution on ships, regulations regarding layout of distribution system on general cargo ships and on oil tankers. Navigation lights and running light indicator panel. Special requirements for lighting on deck and pump house of oil tankers. Wiring appliances. Determination of wire size for AC power circuits.

System earthing: Insulated neutral systems. Resistance earthen systems.

Rules and regulations of classification of societies: Requirements and arrangement of emergency lighting and power by emergency generators and storage batteries. Emergency

generator switch board, circuit diagram for automatic starting in case of failure of main generating plant. Connecting shore supply during dry docking, precautions while taking AC shore supply, arrangement to ensure proper phase connection, arrangement of remote switches for ventilating fans, fuel pumps, lubricating oil pumps and purifiers.

Motor and control equipment: Characteristics of continuous maximum rated machines. Centralised control of motors in machinery spaces. Classes of insulation—A, B, E and temperature rise. Rotary generators.

Recommended Books

□ H D McGeorge. Marine Electricity. Newnes-Butterworth, UK.

Dennis T Hall. Practical Marine Electrical Knowledge. Witherley, UK.

MR 406

MARINE LEGISLATION AND SAFE WATCHKEEPING

Group A

Basic principles to be observed in keeping an engineering watch as per Chapter VIII of STCW 95.

Criteria for composing the engine room watch: Operation and watch requirements. Fitness for duty. Protection for marine environment. Requirement for certification; minimum knowledge requirement for certification—theoretical and practical; Duties and responsibilities concerning safety and protection of environment. Requirements for watchkeeping duties. Physical training and experience in watchkeeping routine. Main and auxiliary machines, pumping systems, generating plant. Safety and emergency procedures. First aid.

Minimum requirement for ratings of engine room watch: Special requirement for engineer officers for oil tankers, chemical tankers and gas tankers. Details of operational guidance for in-charge of an engineering watch.

Engineering watch (underway): General, taking over watch, periodic checks of machinery, engine room log, preventive repair and maintenance, bridge notification. Navigation in congested water and during restricted visibility, calling the attention of the Chief Engineer Officer, watchkeeping personnel.

Group B

Engineering watch (unsheltered anchorage): Conditions to be ensured. Watchkeeping (in port), watch arrangements, taking over the watch; keeping a watch. Oil, chemical and gas tankers—principles, characteristics of cargo, toxicity hazards; safety equipment; protection of personnel. Pollution.

Shipboard applications: Regulations and codes of practice; ship design and equipment of oil, chemical and gas tankers; ship operation, repair and maintenance; emergency operations; training of other personnel. Requirement of continued updating

of proficiency. Modifications of STCW vide June 1995 conference.

ISM code: Safety concept on board a merchant vessel and basic working knowledge of the relevant IMO conventions like SOLAS, MARPOL, LOADLINE, TONNAGE, COLREG, STCW. How are above instruments adopted under explicit/tacit acceptance procedures? Statutory/class certificates required for a foreign-going ship. How obtained? Special/intermediate/annual surveys to be conducted, period of validity, involvement of ISM, issue of SMC.

Recommended Books

- SOLAS, MARPOL, LOADLINE, TONNAGE, STCW, COLREGS. All such instruments overview publications of IMO.
- STCW Code 1995 and allied publications regarding Safety in Watchkeeping.

MR 407

SHIPPING ECONOMICS AND MANAGEMENT

Group A

Brief history of shipping: Modern shipping practice. Marine vehicles and cargoes. Development in shipping and cargo handling. Principal shipping organisations. Liner and tramp shipping services, conference systems. Chartering, charter parties. Theory of freight rates and fares. Rate fixation machinery and government control. Bills of lading. Carriage of goods by Sea Act. Cargo surveys and protests.

Marine insurance: Underwriting and loss adjusting principles applied to marine cargo insurance. Hull policy, particular average. General average, P&I clubs.

Ownerships of vessels, shipping company and its administration. Capitalization and finance. Economics of new and second-hand tonnage. Subsidies.

Group B

Ship operations: Planning sailing schedules. Voyage estimates. Economic factors. Commercial shipping practice. Manning of ships. Engagement and discharge of crew, DLB seaman's welfare.

Merchant Shipping Act: Registration of ship, ship's papers. Port procedures. Pilotage, duties regarding pollution. Collision, explosion, fire, etc. Vessels in distress. Shipping casualties, penalties under Merchant Shipping Act.

Recommended Books

- A E Branch. The Elements of Shipping. Chapman & Hall, London.
- A E Branch. Economics of Shipping & Ship Management. Chapman & Hall, London.

- Kemp and Young. Business Notes for Ship Master. Stanford Maritime, London.
- D H More. Personnel Management in Merchant Ship. Pergamon Press, USA.

MR 408

CONTROL ENGINEERING AND AUTOMATION IN SHIPS

Group A

Control system: Introduction to control terms, block diagrams for control systems, open loop and closed loop feedback control, comparison of closed loop and open loop, feed forward control. Feed forward modification. Regulators and servomechanism. Proportional plus integral plus derivative controls, use of various control modes.

Graphical representation of signals: Inputs of step ramp sinusoid, pulse and impulse, exponential function, etc. Error detector, controller output elements.

Dynamics of a simple servomechanism for angular position control: The torque proportional to error, servomechanism, different response of servomechanism. Technique for improving the general performance of servomechanism. The frequency response test. Series compensation using Nyquist diagram. Parallel compensation using the inverse Nyquist diagram.

Process control systems: Automatic closed loop process. Control system. Dynamic characteristic of processes. Dynamic characteristic of controllers. Practical pneumatic controllers. Electronic instrumentation for measurement and control.

Group B

Analog computing and simulation: Introduction, basic concepts. Analog computers. Simulation. The use of digital computer in the simulation control system. Hybrid computers.

Transmission: Pneumatic and electric transmission, suitability for marine use. Pneumatic and types of controllers, hydraulic, electric and electronic controllers for generation of control action. Time function controllers.

Correcting units: Diaphragm actuators, valve positioners, piston actuators, electro-pneumatic transducers. Electro-hydraulic actuators and electric actuator control valves.

Application of controls on ships: Marine boiler—automatic combustion control, air/fuel ratio control, feed water control, single-, two- and three-element type steam pressure control. Combustion chamber pressure control, fuel oil temperature control, control in main machinery units for temperature of lubricating oil, jacket cooling water, fuel valve cooling water, piston cooling water and scavenge air, fuel oil viscosity control. Bridge control of main machinery. Instrument for UMS classification.

Recommended Books

- D Gray. Centralised Control Systems. Pergamon Press, USA.
- D A Taylor. Maritime Control Practice. Butterworths, UK.

MR 409

MARINE BOILERS

Group A

General considerations governing the design of boilers: Types of marine boilers, comparison of smoke tube and water tube boilers. Destructive and non-destructive tests on plates, rivets, welded seams, classification of societies requirements for boilers construction.

Smoke tube boilers: Various types in marine use, principal dimensions and staying of flat surface of multitubular cylindrical boilers. Vertical auxiliary boilers.

Water tube boilers: General description with sketches of principal types of boilers in marine use, superheater, economizer, air preheater and steam preheater; circulation and use of unheated downcomers in highly rated boilers; superheat temperature control. Attemperators and desuperheaters.

Group B

Waste heat boilers: Waste heat recovery calculation, Lamont exhaust gas boiler. Scotch composite boiler, Cochran exhaust gas and composite boiler, spanner marine exhaust gas and composite boiler. Forced water circulation boiler, double evaporation boiler.

Boiler mountings: Safety valves—improved high lift, full lift and full bore type. Gauge glass—ordinary plate type and remote indicator, automatic feed regulator, three element high and low water level alarms, main steam stop valves, retractible typesoot blower, etc.

Operation, care and maintenance: Precommissioning procedures, hydraulic tests, steam raising and operating procedures, action in the event of shortage of water. Blowing down of boiler, laying up a boiler, general maintenance, external and internal tube cleaning. Tube renewals, etc. Maintenance, inspection and survey of boilers.

Recommended Books

- JH Milton. Marine Boilers. Butterworths, UK.
- G T H Flanagan. Marine Boilers and Mountings. Newnes Butterworths, UK.

MR 410

MARINE IC ENGINES

Group A

Practical diesel engine cycle: 4-stroke and 2-stroke cycles; deviation from ideal condition in actual engines; limitation in

parameters, timing diagrams of 2-stroke and 4-stroke engines. General description of IC engines—marine diesel engine of M A N, Sulzer, B & W make, etc. Comparative study of slow speed, medium speed and high speed diesel engines and suitability and requirements for various purposes. Special features of various types of engines.

Constructional details of IC engines: Principal components. Jackets and liners, cylinder heads. Pistons, crossheads, connecting rods, bed plates, A-frames. Welded construction for bed plates and frames. Tie rods.

Scavenging and supercharging system: Scavenging arrangements in 2-stroke engines, air charging and exhausting in 4-stroke engines; various types of scavenging in 2-stroke engines, uniflow, loop, cross loop and reverse loop scavenging, their merits and demerits, scavenge pumps for normally aspirated engines, under piston scavenging, scavenge manifolds. Turbocharger and its details.

Supercharging arrangements: Pulse and constant pressure type and their relative merits and demerits in highly rated marine propulsion engines. Air movements inside the cylinders.

Combustion of fuels in IC engines: Grades of suitable fuels. Preparation of fuels for efficient combustion. Fuel atomisation and requirements of fuel injectors. Design aspects of combustion chamber. Compression pressure ratio and its effect on engines. Reasons for variation in compression pressure and peak pressure, ignition delay after burning.

Group B

Cooling of IC engines: Various cooling media used and their merits and demerits, cooling of pistons, cylinder jackets and cylinder heads, coolant conveying mechanism and systems, maintenance of coolant and cooling system.

Safety and prevention of mishaps in IC engines: Causes and prevention of crank-case explosions, and scavenge fires. Detection and safety fittings provided to prevent damage.

Fuel pumps and metering devices: Jerk and common rail systems; fuel injection systems. Helical groove and spill valve type fuel pumps. System for burning heavy oil in slow and medium speed marine engines.

Maneuvering systems: Starting and reversing systems of different marine diesel engines with safety provisions.

Indicator diagrams and power calculations: Construction details of indicator instrument. Significance of diagram power calculations, fault detection, simple draw cards and out-of-phase diagrams. Power balancing, performance characteristic curves, test bed and sea trials of diesel engines.

Lubrication systems: Lubrication arrangement in diesel engines including coolers and filters cylinder, lubrication, liner wear mechanism and preventive measures, combinations of lubricating oil and its effect and preventive measures.

Medium speed engines: Different types of medium speed

marine diesel engines, couplings, and reduction gears used in conjunction with medium speed engine, development in exhaust valve design. V-type engine details.

Automation in modern diesel engine plants: Remote operation alarm and fail safe system, governors and their basic functions. Constant speed and overspeed governors. Constructional details and hunting of governor.

Recommended Books

- John Lamb. Marine Diesel Engines. Charles Griffin, UK.
- C C Pounder. Marine Diesel Engines. Newnes-Butterworth, UK.
- D K Sanyal. Marine Diesel Engines. Bhandarkar Publications, Mumbai.
- Southern. Marine Diesel Engines. James Munro, UK.
- Reeds: Vol 12 (Revised Edition). Reeds Publications, UK.

MR 411

MARINE POWER TRANSMISSION

Group A

Running of 2-stroke diesel engine (coupled to alternator): Methods of starting, running under different load conditions (load on the alternators), watchkeeping and recording of the temperatures, pressures on different meters on the diesel engine instrument panel and switch board. Looking after the auxiliary machinery, viz., air compressor, cooling water pump and lubricating oil pump.

Boiler operation: Raising steam from cold condition upto its working pressure and maintaining the same while operating the reciprocating engine and the auxiliary machinery, maintenance schedule for the Scotch boiler.

Blowing of gauge glasses with precautions involved. Necessity and procedure of cross blowing. Overhauling of mountings. Dismantling, overhauling and adjustment of high lift safety valve. Studying the working of boiler plant auxiliary machinery.

Hydraulic transmission of power: Hydraulic motors, valves, types of hydrostatic drives. Types of hydraulic transmission systems—multimotor open-circuit and closed-circuit systems. Applications of hydraulic transmission. Advantages and disadvantages of hydrostatic transmission.

Group B

Rotodynamic transmission: Hydraulic coupling, torque converter and characteristics of hydraulic coupling and torque converter. Linear transmission of hydraulic power, circuit for devices like hydraulic press, jack, accumulator, intensifier and hydraulic lift.

Fluid power: Introduction. Applications of control systems. Control signals Hydraulic servomechanisms Servo valves, valve

operated servomechanisms and bumpcontrolled servomechanisms.

DC and AC transmission and distribution: Two wire and three wire dc system, use of balancer, ac transmission—single phase and three phase, three-wire and four-wire distribution, comparison of dc and ac transmission, effect of voltage drop, copper utilisation under different systems, single and double fed distributors, fuses, dc air circuit breaker, ac air and oil circuit breakers.

Recommended Book

- J Cowley. Running and Maintenance of Marine Machinery. IME, London.

MR 412

DOUBLE HULL TANK VESSELS

Group A

Origin double hull ships, their usefulness and superiority over conventional single skin ships, use of double hull tank ships for transport of different types of commodities, prevention of oil-spill and pollution of sea, IMO requirements, schedule for phasing out single hull tank vessels of different sizes.

Design considerations, main dimension, hull-weight estimate, double hull requirements, minimum depth of double bottom tank, wing tank width, clearance for inspection, etc., maximum cargo tank size, capacity, effect of free surface, damage stability, hydrostatically balanced loading, slashing loads, its elimination or minimisation.

Group B

Structural design, non-uniform and uniform stress distribution, unidirectional (longitudinal) structural members, elimination of transverse structural members (except transverse bulkheads), minimisation of structural discontinuities and stress concentration zones, use of steel of higher strength, resistance to grounding and collision, classification society requirements, access to inside and bottom spaces.

Cargo handling system, use of submerged pumps, ordinary pumps or new independent pumps, cargo transfer system, assurance of quality of cargo oil, complete elimination of risk of admixture of different grades of oil, concealed pipelines, easy maintenance, inspection and cleaning, elimination of explosion risks.

Economic aspects, fast loading discharging of oil cargo, quicker cleaning, ballasting and deballasting, larger number of trips per year.

Recommended Books

- Naval Architect. Royal Institute of Naval Architect, UK.
- Marine Engineers Review. Institute of Marine Engineers.

RULES FOR THE CONDUCT OF EXAMINEES IN THE EXAMINATION HALL

An examinee shall strictly follow the following rules in the examination hall :

1. He shall not carry into his seat any material except his Admit Card, valid Identity Card, pen, pencil, drawing instruments and non-programmable calculator.
Tables, when permitted to be used by an examinee, will be provided by the Institution.
2. An examinee will be permitted to enter the examination hall 15 minutes before commencement of the examination, but shall not be admitted to the examination hall after half an hour from the commencement of the examination.
3. An examinee must check before using the answer-book that the answer-book supplied to him is numbered, bears 'IE' perforation mark at the top right-hand corner, contains all the pages in sequential order between the covers, the staples for stitching are intact and there is no defect in the answer-book.
The invigilator should be requested by the candidate to replace his answer-book, if defective in any way, before use.
Use of defective answer-books, not authenticated by the invigilator, shall be considered as a case of adopting unfair means.
4. An examinee is required to write his membership number, roll number and subject of the examination in the respective space provided on the cover of the answer-book. If these details are not correctly filled-in, the answer-book shall be rejected.
Disclosing of name, signature, or anything leading to the disclosure of identity of the candidate anywhere in the answer book shall be considered as a case of adopting unfair means.
5. An examinee must use English for all examinations unless prior permission of the Institutions to use any regional language or Hindi has been obtained.
6. The answers should be properly numbered corresponding to the serial number of the questions. Examinees are required to use the pages of the answer-book serially leaving no page blank. All blank pages in the answer-book should be crossed by the examinee, after attempting all the questions.
7. An examinee must not communicate with any other examinee during the hours of examination. The Institution reserves the right to take any action as may be deemed proper when an examinee is detected during or after the examination in any one or more of the following offences: (a) helping another examinee or (b) attempting to obtain unfair assistance or using unfair means or (c) writing any objectionable or improper remarks in the answer-book or (d) attempting to render identification of the answer-book impossible either quoting false roll number or membership number or intentionally omitting the same or (e) detaching pages from the answer-book or (f) replacement of the answer-book or (g) writing on any material other than the answer-book or (h) impersonation or (i) giving threat or using any objectionable or improper remarks to any one in the examination hall or (j) damaging the property in the examination hall or (k) request for marks/ grace or (l) any other misconduct.
8. No part of answer-books, drawing sheets, etc supplied to an examinee in the examination hall should be taken out by the examinee.
9. No examinee shall be permitted to leave the examination hall under any circumstances till half an hour has elapsed from the commencement of examination. Under unavoidable circumstances, an examinee may, with the permission of the invigilator, be allowed to leave the examination hall temporarily submitting his answer-book and the question paper to the invigilator after expiry of not less than 30 minutes. Further, no examinee shall be permitted to leave finally the examination hall without submitting his answerscript to the invigilator until an hour has elapsed from the commencement of the examination.
10. In case any material defect is found in the question paper, the examinee should bring in the notice of the invigilator immediately for remedial action.
11. Notwithstanding the issue of Admit Card, the Institution shall have the right, for any reason which may appear sufficient, to cancel the admission of any examinee whether before, during or after the examination.
12. Any violation of any of the rules of examinations shall make an examinee liable for penal measures and punishment as may be decided by the Council of the Institution.
13. The District Court at Alipore, 24-Parganas (South), West Bengal, shall have the exclusive jurisdiction in matters arising out of the conduct of Institution Examinations and/ or penal measures or any decision of the Council of the Institution giving or conferring punishment to any examinee.



REVISED PROFORMA FOR REGISTRATION OF SECTION B

Dear Sir

I am sending the application for Registration of Section B duly filled-in with demand draft for Rs. 4800/- (US\$ 300 for overseas candidates) The fee includes Rs.1800/- for upgradation of ST/T member after passing of Section B Examination to the grade of AMIE. The information provided by me in the application are correct to the best of my knowledge. [Fee for Registration of Section B for Associate Members/Members/Fellows is Rs. 3000/- (US \$ 200 for overseas candidates)].

1. Name ----- Membership No. -----
 2. Passed Section A in ----- with Roll No. -----

3. Choice of Engineering Branch (Code No. only)			Code No. of Optional Subjects Choises			
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Bank Draft No. ----- dated ----- for -----
 Full signature of the candidate with date

CERTIFICATE OF ENGAGEMENT

(to be filled-in by the Engineer under the candidate is working)

1. Name of the organization (in BLOCK letters)
 2. Address of the organization (in BLOCK letters)
 3. Name of the organization (mark ✓ in the relevant box) : ☐ Company ☐ Firm ☐ Statutory Body
 Government Dept. ☐ Public Sector Undertaking ☐ Research Organisation ☐ Statutory Body
 4. Nature of activities of the organization -----
 5. No. of Employees -----

I certify that Shri/Ms..... who has passed Section A Examination of the Institution of Engineers (India) is engaged/receiving training in this organization under me since..... as..... (designation). His date of appointment is

SEAL OF THE

ORGANISATION

 (Full Signature of the Certifying Engineer & Date)

Designation -----

Membership No. FIF/MIE/AMIE/AIE -----

..... (DO NOT TEAR)

Specimen Signature of the ⇒
 applicant
 (Preferably in English)



The signature should not be long
 the box (use black ink only)

Passport size
 photo to be
 pasted here.
 Do not sign on
 the photograph.

Name (in Capital Letter)	Membership No.	Signature (preferably in English) with date

Note : This photograph and signature are to verified by the supporter, who must be a Corporate Member in the grade of FIE/MIE/AMIE only

IMPORTANT INSTRUCTIONS

1. For Branch Code and Subject Codes, please refer Rules (Vol.1) effective from summer 2005 examinations as per Revised Syllabi. Also available at www.ieindia.org-Academic-Information-Course content.
2. A candidate is required to send a demand draft of 4800/- towards registration fee with application form.
3. Candidate is expected to be engaged in engineering profession with a registered engineering establishment. As such the signature of the Engineer/ Employing Authority is prerequisite in the application form. **Certification by T/ST members will not be accepted.**
4. Candidate is required to opt three optional subjects from any one group (refer Rules, Vol.1).
5. Please affix one passport size photograph on the specified space. No separate Identity Card will be issued for Section B Examination. You will have to use the existing Identity card for Section B examinations as well.
6. In case your recorded address is changed, please fill up the form for change of address/replacement of Identity Card available in www.ieindia.org-Membership-Downloads.
7. Demand Draft(s) should be drawn in favour of 'The Institution of Engineers (India)' payable at Kolkata.
8. Please send the filled-in application form with demand draft to The Assistant Director (EEA), The Institution of Engineers (India), 8 Gokhale Road, Kolkata 700020 by registered post/speed post/courier super scribing on the envelope 'APPLICATION FOR REGISTRATION OF SECTION B'

APPLICATION FORMAT FOR EXAMINATION RE-REGISTRATION/PREATURE RE-REGISTRATION

The Director (EEA)
The Institution of Engineers (India)
8, Gokhal Road
Kolkata - 700 020

For Office Use Only

Dear Sir,

You are requested to consider my application for Examination Re-registration/premature re-registration for Section A / Section B Examination. I give below the following factual information as (3) marked in the appropriate box :

1. My six-year period to pass Section A / Section B Examination in Revised Scheme was expired in Winter _____ Examination.
2. I passed Section A Examination in Summer/Winter _____
3. I wish to apply for premature examination re-registration. **(Refer instructions overleaf).**
4. My membership grade and no. is _____

Stamp Size
Photograph to
the pasted here

I also hereby agree that exemption in subject(s) secured during the stipulated period of six years or expiry of five years, as applicable, in Section A / Section B Examination shall be forfeited once my application for Examination Re-registration/ Premature Re-registration is accepted by the Institution. I shall not claim in future to carry forward such exemptions.

- a) I agree that after re-registration, my six years period will be counted from next summer examination immediate to the year of expiry of my previous six years irrespective of month and year of submission of application.
- b) I agree that after premature re-registration during my six years period of six years, my six years period will be counted from summer examination of the year the application has been processed.

Full Name (block letters) _____

Recorded Address (block letters) _____

(For change of Address see overleaf) _____

Phone/Mobile _____

E-mail _____

Full Signature of Candidate with Date _____

Encloser : As tick (3) marked below

I am enclosing following documents for your kind consideration (tick (3) appropriate box)

- ☐ Demand Draft of Rs. 3000/- (Only 280/- for re-registration fee) (Draft No. _____) in favour of 'The Institution of Engineers (India)', payable at Kolkata for Examination Re-registration.
- ☐ Photocopy of my Section A pass marks/percentage for Section B candidates only.
- ☐ Photocopy of my Identity Card.

- Note :**
1. Submission of application form with requisite fee to be sent back at the Headquarters of the Institution latest by 10 April for Summer Examination and 10 October for Winter Examination.
 2. Candidates for Section B must submit Registration Form for Section B (in form available on the website) with requisite fee.
 3. No service identity card will be issued after re-registration. In case of candidate desire to change the address/replace the identity card/report lost of identity card, please approach Membership Department with relevant application form available in website www.ieindia.org.

Applicant Name : _____

Applicant Membership Grade and No. _____

Specimen Signature
of the Applicant
(in English only)



The signature should not be long the box
(use black ink only)

Passport size
photograph to be
pasted here
(do not sign on
the photograph)

Supporter : Verified the photograph and signature of the applicant

Name (in Capital)	Membership No.	Signature (in English only) with date
_____	F/M/AM _____	_____

Note 1 : The photograph and signature are to verified by the supporter, who must be a Corporate Member in the grade of FIE/MIE/AMIE only.
Form No. EXAM/05
Rev 06/01112016

PREMATURE RE-REGISTRATION

Instructions:

Eligibility : Candidates be permitted to apply for premature registration, after the expiry of five years of stipulated six years period when they have not sufficient time to pass the balance subjects of Section A/Section B examination. Such candidates may submit their premature re-registration form for another six years period to appear afresh in all subjects of Section A/Section B with the following condition(s).

Condition:

For Section A (Non-diploma)

Candidates passed only one subject in Section A (Non-diploma) till the expiry of five years of stipulated six years period, are eligible to apply for premature re-registration. **[Candidates passed two or more subjects in Section A (Non-diploma) after the expiry of five years of stipulated six years period are not eligible to apply for premature re-registration.]**

For Section A (Diploma)

Candidates in Section A (Diploma) are not eligible to apply for premature re-registration.

For Section B

Candidates, who are unable to pass any subject in Section B till the expiry of five years of stipulated six years period, are eligible to apply for premature re-registration. **[Candidates passing one or more subject(s) in Section B after the expiry of five years of stipulated six years period are not eligible to apply for premature re-registration.]**

- Six year period shall be counted from Summer examination of the year in which a candidate submits his/her application forth is purpose.
- For Section A candidates, subject exemption, if any, shall be forfeited after premature re-registration.
- For Section B candidates, pass status of Section A examination will remain unaltered.

8, Gokhale Road, Kolkata - 700 020

SUMMER / WINTER 20

[illegible][illegible][illegible]

Engineering
Branch Code
(CH=04, CV=05,.....)

With Roll No.

* For examination,

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 refer Rules : Vol. 1 effective from Summer 2005 Examination

With Roll No.

Enclo : Demand draft of Rs. _____ no. _____ dated ____/____/____/____
drawn on _____ (Bank) in favour of
'The Institution of Engineers (India)', payable at kolkata.

**EXAMINATION AID OTHER FEE AND COST OF PUBLICATIONS
REVISED FEE STRUCTURE FOR SECTIONS A fa B EXAMINATIONS**

Examination Fee	For India and Nepal (Rs.₹)	For Overseas Centres (US \$)
Section A (Non-Diploma Stream)	3000	225*
Section A (Diploma Stream)	3000	225*
Section B	3000	225*
Provisional Appearance (Section 'A' / 'B')	1500	150
Appearance in Additional Subject (per subject)	500	30*

* Effective from Winter 2018 Examination.

Fee for other Examination-related Services	For India and Nepal (Rs.₹)	For Overseas Centres (US \$)
Registration for Section B'	4800	300
Fee for Laboratory Experiments	7000	400
Examination Re-registration (six years)	3500	280
Fee for Project Work	3000	200

Note : For corporate members appearing in additional branch, Section B registration fee is (Rs. *) 3000/- (US \$ 200 for overseas candidate)

Fee for Duplicate Marksheet/Grade Card and Certificate	For India and Nepal (Rs.₹)*	For Overseas Centres (US \$) **
Marksheet/Grade Card (current session)	25	5
Marksheet/Grade Card (previous session)	100	10
Marksheet/Grade Card (over 20 years old)	1000	100
Pass Certificate	500	50
Pass Certificate (over 20 years old)	1000	100
Identity Card	150	10
Transcript (per copy)	500	50
Transcript (per copy over 20 years old)	1000	
No Objection Certificate #	500	40
Appearance Certificate	200	20
Language Certificate	200	20
Fee for verification of educational credentials	600	60

** including postage by Air Mail.

Effective from 01 Jan 2014

COST OF OTHER PUBLICATIONS

T / ST members of the Institution may obtain the following documents on payment at the following rates :

INDIA, NEPAL AND BHUTAN OTHER COUNTRIES				(including postage)
Item	Cost (Rs. ₹)	Postage by Registered Post (Rs. ₹)	Total (Rs. ₹)	Cost (US \$)
Study Material of Section A (Diploma)	2200	...	2200	220*
Prospectus with the T / ST Form	375	...	375	35*
Individual book on each subject	550	...	550	55*
Old Question Papers (Section A -Diploma)	25	30	55	5
Old Question Papers (Section A - Non-Diploma)	40	35	75	5
Old Question Paper (Section B)	40	50	90	5
Study Material of Section B per subject	650	--	650	60*

* Inclusive of Postage.

All payments for different items as mentioned above are to be made through demand draft drawn in favour of The Institution of Engineers (India), payable at Kolkata. Money Orders / Cheques / Postal Orders will not be accepted.

The candidate's name along with the membership number, if applicable, are to be written on reverse of the demand draft.

The fee structure may be revised by the Council without assigning any reason. Any such revision shall be duly notified in the Technicians' Journal.

Payment Gateway for Guests and Members

IMPORTANT INSTRUCTION TO CANDIDATES

- Fee will not be refunded or adjusted for submission of duplicate examination form.
- Do not staple the draft along with the letter/examination form. Use gem clips only to facilitate quick detachment of the drafts.
- Fee for rejected examination forms will not be adjusted to any account. The charge of Rs. (₹) 150/- only for processing. The examination form shall be deducted while refunding the examination fee.
- In case a candidate claims that inspite of submitting an examination form in conformity with Rule 3.1, he has neither been provided with Admission Card nor any information about rejection of his application, he can submit a fresh examination form along with a demand draft of Rs. (₹) 1500/- only, with the photocopies of his original examination form, details of the demand draft and a copy of the postal receipt to the Officer-in-Charge for provisional appearance in the examination. In case the candidate's claim is found not to be in order, the fee deposited by him shall be forfeited and his appearance shall be treated as irregular.
- Programmable calculator and mobile phone are not permitted to use in the examination hall. Non-programmable calculator may only be allowed.
- Design Data Book is not permitted to use in the examination hall unless stated in the question paper.
- Request for change of subjects shall not be entertained after submission of examination form.

IEI EXAMINATION CENTRES

Section A/Section A (Diploma)/Sections A & B Examination will be conducted at the following locations with the scheme/s as stated below until further notification:

Centre Code	Place	Scheme/s	Centre Code	Place	Scheme/s
001	KATHMANDU	All Schemes	462	BHOPAL	All Schemes
002	ABU DHABI		482	JABALPUR	
003	BAHRAIN		490	BHILAI	
005	KUWAIT		492	RAIPUR	Section AD
110	DELHI	Section AD	500	HYDERABAD	All Schemes
121	FARIDABAD		516	KADAPA	Section AD
132	KARNAL	All Schemes	517	TIRUPATI	All Schemes
141	LUDHIANA		520	VIJAYAWADA	Section AD
160	CHANDIGARH		530	VISAKHAPATNAM	All Schemes
171	SHIMLA		560	BENGALURU	
180	JAMMU	Section AD	570	MYSORE	Section AD
190	SRINAGAR		580	DHARWAD	
201	GHAZIABAD	Section AD	600	CHENNAI	All Schemes
202	ALIGARH	Section A	607	NEYVELI	Section AD
208	KANPUR	All Schemes	620	TIRUCHIRAPALLI	All Schemes
211	ALLAHABAD		625	MADURAI	
221	VARANASI		641	COIMBATORE	
226	LUCKNOW		673	KOZHIKODE	
231	ANPARA	Section AD	682	KOCHI	Section AD
243	BARE ILLY		695	THIRUVANANTHAPURAM	
247	ROORKEE	All Schemes	700	KOLKATA	
248	DEHRADUN		713	DURGAPUR	
302	JAIPUR	Section AD	721	KHARAGPUR	All Schemes
324	KOTA		735	JALPAIGURI	
342	JODHPUR	All Schemes	744	PORT BLAIR	Section AD
380	AHMEDABAD		751	BHUBANESWAR	
390	VADODARA	All Schemes	760	BERHAMPUR	All Schemes
400	MUMBAI		769	ROURKELA	
403	GOA	Section AD	781	GUWAHATI	Section AD
407	BELAPUR		793	SHILLONG	
411	PUNE	Section AD	799	AGARTALA	All Schemes
422	NASHIK		800	PATNA	
431	AURANGABAD	All Schemes	831	JAMSHEDPUR	
440	NAGPUR		834	RANCHI	
452	INDORE	Section AD			

Section A means both Diploma and Non-diploma Streams; Section AD means Section A (Diploma); All schemes mean both Section A and Section B.



Director (EEA)
The Institution of Engineers (India)
8, Gokhale Road
Kolkata - 700 020

Date :

INSPECTION OF ANSWERScript (S)

1. Name of the Candidate

2. Membership No.

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3. Roll No.

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4. Subject Code (s)

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5. Mailing Address

6. E-mail Id

7. Mobile No./Landline No.

[Note:

- a) The fee for inspection of answerscript of **each** subject is Rs 500/- (Rupees Five hundred only). The candidate is required to enclose a **single** demand draft of the requisite fee accordingly, subject to a maximum of Rs 2000/- (Rupees Two thousand only) in favour of "**The Institution of Engineers (India)**" payable at **Kolkata**. The application for inspection of answerscript(s) should reach the above mentioned address **within 15 days** of declaration of the results of the respective session.
- b) Inspection of answerscript shall not tantamount to re-valuation of answerscript. This is only a process of verification of arithmetic correction in totalling of marks and any omission/deletion in evaluation. In case any mistake/deficiency is found, the Institution will correct the same.
- c) There is **no** provision for inspection of answerscript at State / Local centres of this institution. The candidate is required to be present **in person** along with the identity card issued by this institution [no representative(s) under any circumstance will be allowed as per rules] at **IEI HQs in Kolkata** on the particular date and time to be intimated in due course by e-mail and letter. Any request for change of date and time once allotted will not be entertained under any circumstance.]

Enclosed please find a demand draft no.....dated.....for
Rs..... drawn on (Bank) in
favour of "The Institution of Engineers (India)" payable at Kolkata.

IEI/EEA/19
Rev 01/05.10.2016

(Signature of the Candidate)

Change of Branch/Optional Subject (s)

I would like to change my branch/optional subject(s) as per the details given below :

I) BRANCH OF ENGINEERING :

CURRENT

DESIRE TO CHANGE

II) CODE AND NAME OF OPTIONAL SUBJECTS (all three optional subjects are to be mentioned) :

CURRENT

DESIRE TO CHANGE

Names of Subjects

Name of Subjects

My particulars are given below :

NAME (in capital letters)

ADDRESS (in capital letters)Mobile No.Telephone No. _____MEMBERSHIP GRADE AND NO.

Passed Section A in Summer/Winter	with Roll No.
-----------------------------------	---------------

Enclo : Bank Draft No.....dated.....for Rs.4000/- (US\$200 for overseas candidates)
to effect for change as requested above (*Name and Membership no. are to be written on reverse of the bank draft*).

Full Signature of Candidate with Date

EEA/ED/COC/105

Date:

Director (EEA)
The Institution of Engineers (India)
8, Gokhale Road, Kolkata 700020

Dear Sir,

Please arrange to send the study material(s) (V mark) of the following subject(s) of Section B.

Subjects	Codes
Water Resources Systems	(CV 405)
Data Structures	(CP 403)
Programming Languages	(CP 404)
Computer Architecture	(CP 406)
Systems Analysis and Design	(CP 407)
Power Systems	(EL 403)
Electrical Machines	(EL 405)
Measurements and Control	(EL 406)
Electronic Circuits	(EC 406)
Mechanics of Solids	(MC 403)
Thermal Science and Engineering	(MC 405)
Manufacturing Technology	(MC 406)

I enclose a demand draft of Rs. 650.00/ Rs. 1300.00/ Rs. 1950.00/ Rs. 2600.00 for one/ two/ three/ four subjects, as applicable, in favour of The Institution of Engineers (India) payable at 'Kolkata' for this purpose. The details are given below:

Name :

Membership No. :

Mailing Address :

Pin Code :

e-mail ID :

Mobile No. :

[Please note that the study material(s) are sent only to the recorded addresses of the candidates. If there is any change in the addresses of the candidates, they are requested to apply for the change of their respective addresses (application form for change of address can be down loaded from the website of IEI www.ieindia.org under the tab "Academics", click "Downloads" and download it from the 2nd page of "Section B Registration Application Form") along with a demand draft of Rs 150.00 in favour of 'The Institution of Engineers (India)' payable at Kolkata separately]

Encl: Demand Draft of Rs _____ (no. _____)

Signature of the Applicant

Subject(s)

CV 405 EL 405 Membership No.

CP 403 EL 406

CP404 EC 406

Name and Address: _____

CP406 MC403

(in block letters) _____

CP407 MC405

EL 403 MC406

Pin Code

Form No. EXAM/18

Rev 04/04022016