INFORMATION BROCHURE

Organising Institute

Indian Institute of Technology Kharagpur

Kharagpur 721302, India

IISc Bangalore | IIT Bombay | IIT Delhi | IIT Guwahati | IIT Kanpur | IIT Kharagpur | IIT Madras | IIT Roorkee

Version 1.0

Contents as on 1st August, 2021

Abbreviations

B.A. – Bachelor of Arts

B.Arch. – Bachelor of Architecture

B.Com.– Bachelor of Commerce

B.E. – Bachelor of Engineering

B.Sc.–Bachelor of Science

B.Tech. – Bachelor of Technology

CBT – Computer Based Test

EWS – Economically Weaker Section

GATE – Graduate Aptitude Test in Engineering

GoI – Government of India

IB – Information Brochure

ID – Identity Document

IISc – Indian Institute of Science

IIT – Indian Institute of Technology

MCQ–Multiple Choice Questions

M.E. – Master of Engineering

MoE – Ministry of Education (erstwhile MHRD)

M.Sc. – Master of Science

MSQ–Multiple Select Questions

M.Tech. – Master of Technology

NAT–Numerical Answer Type

NCB – National Coordination Board

OBC-NCL– Other Backward Class- Non Creamy Layer

OI – Organising Institute

Ph.D. – Doctor of Philosophy

PSU – Public Sector Undertaking

PwD – Person with Disability

SC – Scheduled Caste

ST – Scheduled Tribe

Highlights of GATE 2022

- Dates of examination: Saturday 5th, Sunday 6th, Saturday 12th and Sunday 13th February, 2022. There are two sessions (forenoon and afternoon) each day.
- Fully Computer Based Test (CBT).
- Two NEW subject papers are introduced:
  i. Geomatics Engineering (GE)
  ii. Naval Architecture and Marine Engineering (NM)
- Total number of subject papers: 29.
- All Test Papers of GATE 2022 examinations will be entirely of objective type. The pattern of questions will include some Multiple Choice Questions (MCQ), while the remaining questions may include Multiple Select Questions (MSQ) and/or Numerical Answer Type (NAT) questions.
- ONE or TWO subject papers allowed. TWO Paper combinations have to be chosen from the given list of combinations of papers. Final allotment of TWO papers will still be subject to availability of infrastructure and dates.
- Eligibility criteria: A candidate who is currently studying in the 3rd or higher years of any undergraduate degree program OR has already completed any government approved degree program in Engineering / Technology / Architecture / Science / Commerce / Arts is eligible to appear for GATE 2022 examination.
- There is NO age limit to appear for GATE 2022 examination.
- Applications will be accepted ONLINE only through GATE 2022 website (https://gate.iitkgp.ac.in). Even if a candidate is appearing for TWO papers, the candidate should fill ONLY ONE application form.
- GATE 2022 score card will remain valid for THREE years from the date of announcement of results.
- Depending on COVID-19 situation, the schedule of the GATE 2022 examination may change.
- Details are available at the official website: https://gate.iitkgp.ac.in
- Organising Institute: Indian Institute of Technology Kharagpur (IITKGP).

Pattern of Examination

Particulars	Details
Examination Mode	Computer Based Test (CBT)
Duration	3 Hours
Number of Subjects (Papers)	29
Sections	General Aptitude (GA) + Candidate's Selected Subject
Type of Questions	(a) Multiple Choice Questions (MCQ) (b) Multiple Select Questions (MSQ) and/or Numerical Answer Type (NAT) Questions
Questions for testing these abilities	Recall Comprehension Application Analysis & Synthesis
Number of Questions	10 (GA) + 55 (subject) = 65 Questions
Distribution of Marks in all Papers EXCEPT papers AR, CY, EY, GG, MA, PH, XH and XL	General Aptitude: 15 Marks + Engineering Mathematics: 13 Marks + Subject Questions: 72 Marks = Total: 100 Marks
Distribution of Marks in papers AR, CY, EY, GG, MA, PH, XH and XL	General Aptitude: 15 Marks + Subject Questions: 85 Marks = Total: 100 Marks
Marking Scheme	Questions carry 1 mark and 2 marks
Negative Marking	For a wrong answer chosen in a MCQ, there will be negative marking. For 1-mark MCQ, 1/3 mark will be deducted for a wrong answer. Likewise, for 2-mark MCQ, 2/3 mark will be deducted for a wrong answer

Paper Code	General Aptitude (GA) Marks	Subject Marks	Total Marks	Total Time (Minutes)
AE, AG, BM, BT, CE, CH, CS, CY, EC, EE, ES, EY, IN, MA, ME, MN, MT, NM, PE, PH, PI, TF, ST	15	85	100	**180**
AR [Part A + Part B1 or B2 (B1: Architecture or B2: Planning)]	15	60 + 25	100	**180**
GE [Part A + Part B (Section I or Section II)	15	55 + 30	100	**180**
GG [Part A + Part B (Section 1: Geology or Section 2: Geophysics)]	15	25 + 60	100	**180**
XE (Section A + Any TWO Sections)	15	15 + (2 x 35)	100	**180**
XH (Section B1 + Any ONE Section)	15	25 + 60	100	**180**
XL (Section P + Any TWO Sections)	15	25 + (2 x 30)	100	**180**

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Note: Zonal GATE offices (IITs & IISc) NEVER sell or advertise any GATE examination papers or syllabus. Candidates MUST be aware about frauds in the market/fake emails/fake SMS related to this aspect. Any individual/organization claiming to sell /distribute GATE papers in the name of IITs & IISc will be subjected to appropriate legal actions.

1. Introduction

Graduate Aptitude Test in Engineering (GATE) is a national examination conducted jointly by the Indian Institute of Science (IISc), Bangalore and the seven Indian Institutes of Technology (at Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) on behalf of the National Coordination Board (NCB)-GATE, Department of Higher Education, Ministry of Education (MoE), Government of India.

Qualifying in GATE is a mandatory requirement for seeking admission and/or financial assistance to: (i) Master's programs and direct Doctoral programs in Engineering/Technology/Architecture and (ii) Doctoral programs in relevant branches of Arts and Science, in the institutions supported by the MoE and other Government agencies. Even in some colleges and institutions, which admit students without MoE scholarship/assistantship, the GATE qualification is mandatory. Further, many Public Sector Undertakings (PSUs) have been using the GATE score in their recruitment process.

The information in this brochure is mainly categorized into Pre-Examination (Eligibility, Application Submission, Examination Centres, etc.), Examination (Pattern, Marks / Score, etc.) and Post-Examination (Answers, Contests, Results, Scorecard, etc.) sections.

Note: Candidates opting to appear in TWO subject papers must have a primary choice of paper, which will be their default choice and second choice of paper, which has to be chosen from the allowed combinations given in Table 4.3. Combinations other than the listed ones are NOT allowed. Under unforeseen circumstances, GATE 2022 committee has the right to remove certain combinations listed in Table 4.3 at a later date. In such cases, the fee paid towards the second paper will be refunded to the candidates. Also note that the examination centre for candidate to appear for the second paper may be different (but in same city) from that for the first paper due to the infrastructure and scheduling constraints. GATE committee is NOT liable for any legal obligations related to this issue.

Disclaimer:

GATE is NOT an admission ensuring examination. Qualifying in GATE examination does NOT guarantee admission / scholarship. Admission to any institute is fully dependent on the admitting institute's criteria for educational qualification. Similarly, GATE qualification does not assure a Public Sector Undertaking (PSU) job, as it depends on the recruitment procedure of the concerned PSU. GATE committee is NOT liable for any legal obligations related to admission / job.

2. About GATE

Graduate Aptitude Test in Engineering (GATE) is a national examination on the comprehensive understanding of the candidates in various undergraduate subjects in Engineering / Technology / Architecture and post-graduate level subjects in Arts, Commerce and Science. GATE 2022 will be conducted for **29 subjects** (also referred to as "papers") and it would be distributed over **Saturday 5th, Sunday 6th, Saturday 12th and Sunday 13th of February 2022**. The GATE examination is conducted in different cities across India. The examination would be purely a Computer Based Test (CBT).

The GATE score would reflect the relative performance level of the candidate in a particular subject, which is quantified based on several years of examination data. Note that the GATE 2022 score is valid for THREE YEARS from the date of announcement of the results**. No information on the GATE 2022 score will be available after this period.**

2.1 Administration

GATE is administered jointly by the Indian Institute of Science (IISc), Bangalore and seven Indian Institutes of Technology (namely, IITs at Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee). The GATE Committee, which comprises of representatives from the administering institutes, is the sole authority for regulating the examination and for declaring the results. For administrative purposes, the examination cities in India are segregated into eight zones. The operations related to GATE, in each of the eight zones, are managed by a Zonal GATE Office at the administering institute (IIT or IISc).

Table 2.1 gives details of the zones and the corresponding administering institutes.

One of the administering institutes is designated as the Organising Institute (OI), and it would be responsible for the end-to-end process, as well as, the overall coordination amongst the administering institutes for conducting the GATE Examination. The Organising Institute for GATE 2022 is Indian Institute of Technology Kharagpur (IITKGP).

Table 2.1. Zones and The Corresponding Administrative Institutes for GATE 2022

Zone	Administering Institute	Zonal Websites
Zone-1	Indian Institute of Science Bangalore	http://gate.iisc.ac.in
Zone-2	Indian Institute of Technology Bombay	https://gate.iitb.ac.in/
Zone-3	Indian Institute of Technology Delhi	http://gate.iitd.ac.in
Zone-4	Indian Institute of Technology Guwahati	http://iitg.ac.in/gate-jam
Zone-5	Indian Institute of Technology Kanpur	http://gate.iitk.ac.in
Zone-6	Indian Institute of Technology Kharagpur	http://gate.iitkgp.ac.in
Zone-7	Indian Institute of Technology Madras	http://gate.iitm.ac.in
Zone-8	Indian Institute of Technology Roorkee	http://gate.iitr.ac.in

2.2 Scholarship / Assistantship for Postgraduate Programs

To avail the financial assistance (scholarship/assistantship), the candidate must first secure the admission to a program in one of the central government supported institutes, by a procedure that could vary from institute to institute. Depending upon the norms adopted by a specific institute or department of the institute, the candidates may be admitted directly into a course based on their performance in GATE only; or based on their performance in GATE and an admission test/interview conducted by the department to which they have applied and/or the candidate's academic record. In

the test / interview based selection procedure, as per the MoE guidelines, a minimum of 70% weightage will be given to the performance in GATE and the remaining will be given to the candidate's performance in test/interview and/or academic record. However, the admitting institutes could prescribe a minimum passing marks in the test/interview.

Candidates are advised to seek the complete details of the admission procedures and the availability of MoE scholarship/assistantship from the corresponding admitting institutions. The criteria for postgraduate admission with scholarship/assistantship could be different for different institutions. The management of the post-graduate scholarship/assistantship is also the responsibility of the admitting institution. Similarly, reservation of the seats for different categories will be as per the policies and norms of the admitting institution and the Government of India rules.

The admitting institute may also specify the number of candidates who will be provided financial assistance (scholarship), if admission is secured. Qualification in GATE is also a minimum requirement to apply for various fellowships awarded by many Government organizations.

Note: 1. Call for admissions to M.Tech. / Ph.D. or any other program will be advertised separately by the respective institutions and GATE committee is NOT responsible for the admission process.

2. GATE zonal offices will NOT entertain any queries about admission, reservation of seats and/or award of scholarship/assistantship.

3. GATE committee is NOT liable for any legal obligations related to admission.

2.3 Use of GATE Score for Employment

In the past, several Public Sector Undertakings (PSUs) have used GATE score to shortlist the candidates for employment. A few such organizations are: Bharat Heavy Electricals Limited (BHEL), Gas Authority of India Limited (GAIL), Hindustan Aeronautics Limited (HAL), Indian Oil Corporation Limited (IOCL), National Thermal Power Corporation (NTPC), Nuclear Power Corporation of India Limited (NPCIL), Oil and Natural Gas Corporation (ONGC) and Power Grid Corporation of India (PGCI).

Direct recruitment to Group A level posts in Central government, i.e., Senior Field Officer (Tele), Senior Research Officer (Crypto) and Senior Research Officer (S&T) in Cabinet Secretariat, Government of India, is now being carried out on the basis of GATE score. The details of the scheme of recruitment are normally published in National Newspapers / Employment News / Rozgar Samachar by the concerned authority.

Some other Government of India Organizations may also utilize GATE 2022 score for their recruitment purpose.

Note: GATE qualification does not assure a PSU job, as that depends on the recruitment procedure of the concerned PSU. GATE committee is NOT responsible for any employment opportunities. The qualified candidates must check newspapers and other reliable sources for any such information. GATE committee is NOT liable to any legal obligations related to jobs.

3. About GATE 2022

•IIT Kharagpur is the organising institute for GATE 2022.

•Information website for GATE 2022 is https://gate.iitkgp.ac.in

•GATE 2022 will be conducted on 29 subjects (also referred to as "papers").

•Examination for all the 29 subjects (papers) will be conducted as ONLINE Computer Based Test (CBT).

•The online examination papers will contain some questions of (i) Multiple Choice Question (MCQ) type, where only one option out of four options is correct. Remaining questions may be of (ii) Multiple Select Question (MSQ) type, where one or more than one options out of four options is/are correct, and / or (iii) Numerical Answers Type (NAT) where answer must be keyed in by the candidate using a virtual keypad. The candidates will use ONLY an on-screen virtual calculator provided for the examination.

•A candidate can appear in ANY ONE or UP TO TWO papers of the GATE examination. However, note that the combination of TWO papers in which a candidate can appear MUST be selected from the pre-defined list as given in Table 4.3. Even if a candidate is appearing for TWO papers, the candidate should fill ONLY ONE application form.

•GATE 2022 examinations will be held during the forenoon and afternoon sessions on **Saturday 5th, Sunday 6th, Saturday 12th and Sunday 13th of February 2022**.

•Examination for some of the papers in GATE 2022 may be held in multiple sessions. However, a candidate will be required to appear for the examination in ONLY one of the multiple sessions of the same paper.

•Exact details of the complete examination schedule will be notified later on the GATE 2022 website (https://gate.iitkgp.ac.in).

•**Important dates for GATE 2022 are given in Table 3.1.**

Table 3.1 Important Dates Related to GATE 2022

Online Application Process Opens (https://gate.iitkgp.ac.in)	Monday	30th August 2021
Closing Date of REGULAR online registration/ application process	**Friday**	**24th September 2021**
End of Extended period for online Registration / application (with late fee)	**Friday**	**1st October 2021**
Last Date for change of Category, Paper and Examination City (an additional fee will be applicable)	**Friday**	**12th November 2021**
Admit Card will be available for download	**Monday**	**3rd January 2022**
GATE 2022 Examination Forenoon: 9:00 AM to 12:00 Noon (Tentative) Afternoon: 2:30 PM to 5:30 PM (Tentative)	**Saturday** **Sunday** **Saturday** **Sunday**	**5th February 2022** **6th February 2022** **12th February 2022** **13th February 2022**
Announcement of the Results in the Online Application Portal	**Thursday**	**17th March 2022**

Important Note: The health and safety of the candidates are of utmost priority. Due to current COVID-19 pandemic situation, dates mentioned here are subject to change. In rare cases, it may be necessary to postpone the GATE 2022 examination because of situations beyond the control of GATE committee. All updates will be available on the website.

•Candidates have to register and fill the application via ONLINE mode ONLY at GATE 2022 website.

•The entire process of filling up of the application form and uploading of certificates / documents, etc. is in ONLINE mode only. The candidates should NOT send any hard copy of their application forms / documents etc. to IIT Kharagpur or any of the zonal GATE offices.

•The payment of application fees is through electronic mode. If a candidate wishes to appear for TWO papers, the fees to be paid by the candidate will be TWICE of that mentioned for a single paper.

•The Admit Cards for GATE 2022 would be available for download on the GATE 2022 website of IIT Kharagpur only. No printed copy of the Admit Cards will be posted to the candidates.

•The candidate has to appear at the GATE Examination Centre on the date and time specified in the Admit Card.

•No request for any changes in the Centre or Location or Date/Time specified in the Admit Card will be entertained. Similarly, this being an examination body with certain constraints, candidates needing very special or specific facility for the examination may not be entertained (except scribe facility). Hence, candidates are requested to adhere to the facilities that are possible within the ambit and resources of GATE Examination Body.

•Physical calculators, mobile phones, any other electronic/communication devices, wallets, books, papers, loose sheets, data or handbooks, tables, pen/pencil box/pouch, watches of any form etc. are strictly prohibited in exam halls and candidates possessing these (even if not using) will be disqualified.

•Biometric information (such as, Photograph, Iris scan and Fingerprints etc.) for randomly selected candidates may be captured before the start or during the examination.

•In all matters concerning GATE 2022, the decision of the GATE 2022 Committee will be final and binding on all the applicants.

•Although GATE 2022 will be held at different test centres across the country, the Indian Institute of Technology Kharagpur, being the Organising Institute, bears the overall responsibility of conducting GATE 2022. In case of any claims or disputes arising with respect to GATE 2022, it is hereby made absolutely clear that the High Court of Calcutta in Kolkata alone will have the exclusive jurisdiction to entertain and settle them.

•**TWO new papers called "Geomatics Engineering (GE)" and "Naval Architecture and Marine Engineering (NM)" are being introduced in GATE 2022.**

•For candidates appearing for Geology and Geophysics (GG) papers, separate score and ranking will be provided based on their selection of sections (Refer FAQ).

•For candidates appearing for Humanities and Social Sciences (XH) papers, separate score and ranking will be provided based on their selection of sections (Refer FAQ).

•For candidates appearing for Architecture and Planning (AR) papers, separate score and ranking will be provided based on their selection of sections (Refer FAQ).

4. Pre-Examination Related Information

4.1 Eligibility for GATE 2022

Before starting the application process, the candidate must ensure that he/she meets the educational eligibility criteria of GATE 2022.

A candidate who is currently studying in the 3rd or higher years of any undergraduate degree program OR has already completed any government approved degree program in Engineering / Technology / Architecture / Science / Commerce / Arts is eligible for appearing in the GATE 2022 exam.

Disclaimer:

GATE is NOT an admission ensuring examination. Qualifying in GATE examination does NOT guarantee admission / scholarship. Admission to any institute is fully dependent on the admitting institute's criteria for educational qualification. Similarly, GATE qualification does not assure a Public Sector Undertaking (PSU) job, as it depends on the recruitment procedure of the concerned PSU. GATE committee is NOT liable for any legal obligations related to admission / job.

Some of the Professional Societies/Institutions, which conduct examination in various fields of engineering, are as follows.

- The Institution of Engineers (India) (IE)
- The Institution of Civil Engineers (ICE)
- The Institution of Electronics and Telecommunication Engineers (IETE)
- The Aeronautical Society of India (AeSI)
- The Indian Institute of Chemical Engineers, including Polymer and Environmental Group (IIChemE)
- The Indian Institute of Metals (IIM)
- The Indian Institute of Industrial Engineers (IIIE)

However, the candidates who possess certification from any of the professional societies must ensure that those examinations conducted by the societies are approved by MoE/AICTE/UGC/UPSC as equivalent to B.E. / B.Tech. / B.Arch. / B.Planning, etc.

Candidates who have obtained / are pursuing their qualifying degree from countries other than India:

Must be currently in the 3rd or higher years or completed their Bachelor's degree (duration: at least 3 years) in Engineering / Technology / Science / Arts / Commerce.

Details of eligibility criteria are given in Table 4.1. However, any candidate fulfilling the above mentioned criteria is eligible to appear for GATE 2022.

Note: If a candidate is pursuing any higher degree or has already obtained a degree higher than that mentioned in the Table 4.1 the candidate will be allowed to appear in GATE 2022 examination.

Table 4.1 Eligibility Criteria for GATE 2022

Degree/Program	Qualifying Degree/Examination	Description of Eligible Candidates	Expected Year of Completion
B.E. / B.Tech. / B. Pharm.	**Bachelor's degree in Engineering / Technology (4 years after 10+2 or 3 years after B.Sc. / Diploma in Engineering / Technology)**	**Currently in the 3rd year or higher or already completed**	**2023**
B. Arch.	**Bachelor's degree of Architecture (5- year course) / Naval Architecture (4- year course) / Planning (4- year course)**	**Currently in the 3rd year or higher or already completed**	**2024 (for 5-year program), 2023 (for 4-year program)**
B.Sc. (Research) / B.S.	**Bachelor's degree in Science (Post-Diploma/4 years after 10+2)**	**Currently in the 3rd year or higher or already completed**	**2023**
Pharm. D. (after 10+2)	**6 years degree program, consisting of internship or residency training, during third year onwards**	**Currently in the 3rd/4th/5th/6th year or already completed**	**2025**
M.B.B.S.	**Degree holders of M.B.B.S. and those who are in the 5th/6th/7th semester or higher semester of such programme.**	**5th, 6th, 7th or higher semester or already completed**	**2023**
M. Sc. / M.A. / MCA or equivalent	**Master's degree in any branch of Arts/Science/Mathematics/Statistics/ Computer Applications or equivalent**	**Currently in the first year or higher or already Completed**	**2023**
Int. M.E./ M.Tech. (Post-B.Sc.)	**Post-B.Sc Integrated Master's degree programs in Engineering/ Technology (4-year program)**	**Currently in the 1st / 2nd/3rd/4th year or already completed**	**2025**
Int. M.E./ M.Tech. or Dual Degree (after Diploma or 10+2)	**Integrated Master's degree program or Dual Degree program in Engineering/Technology (5-year program)**	**Currently in the 3rd /4th/5th year or already completed**	**2024**
B.Sc. / B.A. / B.Com.	**Bachelor degree in any branch of Science / Arts / Commerce (3 year program)**	**Currently in the 3rd year or already completed**	**2022**
Int. M.Sc. / Int. B.S. / M.S.	**Integrated M.Sc. or 5-year integrated B.S.-M.S. program**	**Currently in the 3rd year or higher or already completed**	**2023**
Professional Society Examinations (equivalent to B.E. / B.Tech. / B.Arch.)	**B.E./B.Tech./B.Arch. equivalent examinations of Professional Societies, recognized by MoE/UPSC/AICTE (e.g. AMIE by Institution of Engineers-India, AMICE by the Institute of Civil Engineers-India and so on)**	**Completed Section A or equivalent of such professional courses**	**NA**

4.2 GATE 2022 Papers

GATE 2022 will be conducted on **29 subjects** (papers). Table 4.2 shows the list of papers and paper codes for GATE 2022. A candidate is allowed to appear in ANY ONE or UP TO TWO papers of the GATE examination. However, note that the combination of TWO papers in which a candidate can appear MUST be from the pre-defined list as given in Table 4.3. Also note that for a paper running in multiple sessions, a candidate will be mapped to appear for the examination in one of the sessions ONLY.

Table 4.2 List of GATE 2022 Papers and Corresponding Codes

GATE Paper	Code	GATE Paper	Code
Aerospace Engineering	AE	Instrumentation Engineering	IN
Agricultural Engineering	AG	Mathematics	MA
Architecture and Planning	AR	Mechanical Engineering	ME
Bio-medical Engineering	BM	Mining Engineering	MN
Biotechnology	BT	Metallurgical Engineering	MT
Civil Engineering	CE	Naval Architecture and Marine Engineering	NM
Chemical Engineering	CH	Petroleum Engineering	PE
Computer Science and Information Technology	CS	Physics	PH
Chemistry	CY	Production and Industrial Engineering	PI
Electronics and Communication Engineering	EC	Statistics	ST
Electrical Engineering	EE	Textile Engineering and Fibre Science	TF
Environmental Science & Engineering	ES	Engineering Sciences	XE*
Ecology and Evolution	EY	Humanities & Social Sciences	XH**
Geomatics Engineering	GE	Life Sciences	XL***
Geology and Geophysics	GG		

Note: "Geomatics Engineering (GE)" and "Naval Architecture and Marine Engineering (NM)" are two new papers introduced in GATE 2022.

*XE Paper Sections	Code	**XH Paper Sections	Code	***XL Paper Sections	Code
Engineering Mathematics (Compulsory) (15 marks)	A	Reasoning and Comprehension (Compulsory) (25 marks)	B1	Chemistry (Compulsory) (25 marks)	P
Any TWO optional Sections (2x35 = 70 marks)		Any ONE optional Section (60 marks)		Any TWO optional Sections (2x30 = 60 marks)	
Fluid Mechanics	B	Economics	C1	Biochemistry	Q
Materials Science	C	English	C2	Botany	R
Solid Mechanics	D	Linguistics	C3	Microbiology	S
Thermodynamics	E	Philosophy	C4	Zoology	T
Polymer Science and Engineering	F	Psychology	C5	Food Technology	U
Food Technology	G	Sociology	C6		
Atmospheric and Oceanic Sciences	H				

*XE (Engineering Sciences), **XH (Humanities & Social Sciences), ***XL (Life Sciences), papers are of general nature and will be comprised of Sections listed in the above table.

Note: Each subject/paper is of total 100 marks. General Aptitude (GA) section of 15 marks is common for all papers. Hence remaining 85 marks are for the respective subject/paper code.

Note: CE, CS, EC, EE and ME papers: Examination MAY be conducted in multiple sessions. However, a candidate is allowed to appear in only ONE specified / assigned session by the GATE committee.

The syllabus for each of the papers is given on GATE website https://gate.iitkgp.ac.in. Making a choice of the appropriate paper in the GATE application is the responsibility of the candidate. Some guidelines in this respect are suggested below.

Candidates are expected to appear in paper(s) appropriate to the discipline of their qualifying degree. However, candidates are free to choose any one or the allowed set of two papers of the GATE 2022 examination as per their admission or employment plan, while keeping in mind the eligibility criteria for the institutions in which they wish to seek admission/employment. For more details regarding the admission criteria in any particular institute, the candidate is advised to refer to the website of that institute.

Candidates must familiarize themselves with the paper code as it is required both during application and examination. As the candidates are permitted to appear in ONE or UP TO TWO papers of the allowed combination of TWO papers (refer Table 4.3) of the GATE 2022, they should make their choice with due care.

If a candidate makes more than one application for the same paper, he/she will be allowed to appear in any one session ONLY. One of the duplicate / triplicate applications will be considered and the remaining applications will be rejected without any refund of application fee.

Table 4.3 Combination of TWO Papers Allowed to Appear in GATE 2022 (subject to availability of infrastructure and schedule)

Code of The First (Primary) Paper	Codes of Papers Allowed as The Second Paper	Code of The First (Primary) Paper	Codes of Papers Allowed as The Second Paper
AE	NM, XE	IN	EC, EE, PH
AG	ES, GE, XE, XL	MA	CS, GE, PH, ST
AR	CE	ME	AE, CH, NM, PI, XE
BM	BT, EC, IN, XL	MN	GE, GG, XE
BT	BM, XL	MT	PH, XE
CE	AE, AR, ES, GE, NM	NM	AE, CE, XE
CH	PE, XE	PE	CH, GG, XE
CS	EC, GE, MA, ST	PH	EC, GE, GG, IN, MA, MT, ST, XE
CY	XL	PI	ME, MT, XE
EC	IN, PH, EE, CS, GE	ST	MA, PH
EE	EC, IN	TF	XE
ES	AG, CE, GE	XE	AE, AG, CH, ME, MN, MT, PE, PI, TF, NM
EY	XL	XH	ST
GE	CE, GG, ES, MN	XL	BM, BT, CY, EY
GG	GE, MN, PE, PH		

Note: Candidates opting to appear in TWO subject papers must have a primary choice of paper, which will be their default choice and second choice of paper, which has to be chosen from the allowed combinations are given in Table 4.3. Combinations other than the listed ones are NOT allowed. Under unforeseen circumstances, GATE 2022 committee has the rights to remove certain combinations listed in Table 4.3 at a later date. In such case, the fee paid towards the second paper will be refunded to the candidates. Also note that the examination centre for candidate to appear for the second paper may be different (but in same city) from that for the first paper due to the infrastructure and scheduling constraints. GATE committee is NOT liable for any legal obligations related to this issue.

4.3 GATE 2022 Examination Cities

Table 4.4 gives a tentative list of the cities (zone-wise) in which GATE 2022 examination is planned to be held. Also given in the table are the details of the Zonal GATE Offices.

Choice of Examination City: A candidate can choose **THREE** cities from the list of examination cities given in Table 4.4. All the three choices must be from the same GATE 2022 zone.

If a candidate chooses a particular city (in a particular zone) as the first choice, then he/she will be able to choose the city of second and third choices ONLY from the same zone. Note that, because of the operational constraints, the GATE Committee reserves the right to add a new city or remove an existing one, and allot a city that may not be from any of the choices selected by the candidate.

4.4 Application Process

Application for GATE 2022 must be submitted ONLINE website (https://gate.iitkgp.ac.in) by paying necessary application fees. The photograph, signature, category certificate (SC / ST / PwD) and / or Dyslexic certificate, wherever applicable, must be uploaded during the online application. **Candidates MUST enter the valid photo identity (ID) number specified in any one of the following IDs**: **Aadhaar-UID (preferable)**, Passport, PAN Card, Voter ID and Driving License. The candidates who do not possess any of these identity cards, may please procure any one of them before making the application. Candidate MUST produce the SAME original valid photo ID proof during the examination for verification purpose. In the absence of the SAME original valid photo ID proof, candidate will NOT be allowed to appear for GATE 2022 examination.

Note: "Candidates applying to GATE are required to apply online only. GATE applications in any other form are unauthorized and not sold".

Table 4.4 Tentative List of Zone-Wise Examination Cities

Zone No.	Zonal GATE Office	Tentative List of Examination Cities/Towns*
Zone-1	**IISc Bangalore** **Bengaluru - 560 012** **Website:** http://gate.iisc.ac.in	Ananthapuramu (AP), Angamaly (KL), Bagalkot (KA), Ballari (Bellary KA), Belagavi (Belgaum KA), Bengaluru North (KA), Bengaluru South (KA), Bidar (KA), Chikkamagaluru (KA), Davanagere (KA), Hassan (KA), Hubballi (Hubli KA), Hyderabad (TS), Kalaburagi (Gulbarga KA), Kannur (KL), Kasaragod (KL), Kolar (KA), Kozhikode (KL), Kurnool (AP), Malappuram (KL), Mangaluru (KA), Manipal (KA), Mysuru (Mysore KA), Palakkad (KL), Payyanur (KL), Port Blair (AN), Shivamogga (Shimoga KA), Thrissur (KL), Tumakuru (KA), Vatakara (KL) - (30 Cities).
Zone-2	**IIT Bombay,** **Powai, Mumbai - 400 076** **Website:** https://gate.iitb.ac.in/	Ahmedabad (GJ), Ahmednagar (MH), Akola (MH), Amravati (MH), Anand (GJ), Aurangabad (MH), Baramati (MH), Bhavnagar (GJ), Bhuj (GJ), Dhule (MH), Gandhinagar (GJ), Goa (GA), Jalgaon (MH), Kolhapur (MH), Mehsana (GJ), Mumbai-Navi Mumbai-Thane (MH), Nagpur (MH), Nanded (MH), Nashik (MH), Pune (MH), Panvel-Raigad (MH), Rajkot (GJ), Ratnagiri (MH), Sangamner-Loni-Shirdi (MH), Sangli (MH), Satara (MH), Solapur (MH), Surat (GJ), Vadodara (GJ), Vasai-Palghar (MH) - (30 Cities).
Zone-3	**IIT Delhi,** **Hauz Khas, New Delhi - 110 016** **Website:** http://gate.iitd.ac.in	Ajmer (RJ), Alwar (RJ), Bikaner (RJ), Faridabad (HR), Greater NOIDA (UP), Gurugram (HR), Hisar (HR), Indore (MP), Jaipur (RJ), Jammu-Samba (JK), Jodhpur (RJ), Kota (RJ), Mathura (UP), New Delhi (DL), Sikar (RJ), Sonepat (HR), Srinagar (JK), Udaipur (RJ), Ujjain (MP) - (19 Cities).
Zone-4	**IIT Guwahati** **Guwahati - 781 039** **Website:** http://iitg.ac.in/gate-jam/	Agartala (TR), Aizawl (MZ), Asansol-Durgapur (WB), Bokaro Steel City (JH), Burdwan (WB), Dhanbad (JH), Dibrugarh (AS), Dimapur-Kohima (NL), Gangtok (SK), Guwahati (AS), Imphal (MN), Itanagar (AR), Jorhat (AS), Kalyani (WB), Muzaffarpur (BR), Patna (BR), Purnea (BR), Shillong (ML), Silchar (AS), Siliguri (WB), Tezpur (AS) - (21 Cities).
Zone-5	**IIT Kanpur** **Kanpur - 208 016** **Website:** http://gate.iitk.ac.in	Agra (UP), Aligarh (UP), Allahabad (UP), Bareilly (UP), Bhopal (MP), Gorakhpur (UP), Gwalior (MP), Jabalpur (MP), Jhansi (UP), Kanpur (UP), Lucknow (UP), Sagar (MP), Satna (MP), Varanasi (UP) - (14 Cities).
Zone-6	**IIT Kharagpur** **Kharagpur - 721 302** **Website:** http://gate.iitkgp.ac.in	Baharampur-Murshidabad (WB), Balasore (OD), Berhampur (OD), Bhilai (CH), Bhubaneswar (OD), Bilaspur (CH), Cuttack (OD), Dhenkanal (OD), Eluru (AP), Hazaribag (JH), Hooghly (WB), Jamshedpur (JH), Kakinada (AP), Kharagpur (WB), Kolkata (WB), Machilipatnam (AP), Raipur (CH), Rajamahendravaram (Rajahmundry AP), Ranchi (JH), Rourkela (OD), Sambalpur (OD), Srikakulam (AP), Tadepalligudem (AP), Vijayawada (AP), Visakhapatnam (AP), Vizianagaram (AP) - (26 Cities).

Zone No.	Zonal GATE Office	Tentative List of Examination Cities/Towns*
Zone-7	**IIT Madras** **Chennai - 600 036** **Website:** http://gate.iitm.ac.in	Alappuzha (KL), Aluva-Ernakulam (KL), Attingal (KL), Chengannur (KL), Chennai South (TN), Chennai West (TN), Chirala (AP), Chittoor (AP), Coimbatore (TN), Cuddalore (TN), Dindigul (TN), Gudur (AP), Guntur (AP), Idukki (KL), Kadapa (AP), Kanjirapally (KL), Kanyakumari-Nagercoil (TN), Karimnagar (TS), Khammam (TS), Kodad (TS), Kollam (KL), Kothamangalam (KL), Kottayam (KL), Madurai (TN), Muvattupuzha (KL), Namakkal (TN), Nellore (AP), Ongole (AP), Puducherry (PY), Salem (TN), Thanjavur (TN), Thiruvananthapuram (KL), Thoothukudi (TN), Tiruchirapalli (TN), Tirunelveli (TN), Tirupati (AP), Vellore (TN), Villupuram (TN), Virudhunagar (TN), Warangal (TS) - (40 Cities).
Zone-8	**IIT Roorkee** **Roorkee – 247 667** **Website:** https://gate.iitr.ac.in	Ambala (HR), Amritsar (PB), Bathinda (PB), Dehradun (UK), Ghaziabad (UP), Haldwani (UK), Hamirpur-Una (HP), Jalandhar (PB), Karnal (HR), Kurukshetra (HR), Ludhiana (PB), Meerut (UP), Mohali-Chandigarh (PB), Moradabad (UP), Muzaffarnagar (UP), NOIDA (UP), Panipat (HR), Pathankot (PB), Patiala-Sangrur (PB), Roorkee (UK), Shimla-Solan (HP), Yamunanagar (HR) - (21 Cities).

This is a tentative list of examination cities, and any changes will be updated on website: https://gate.iitkgp.ac.in

4.4.1 GATE 2022 Application Fee

Details of the application fee per candidate per paper are given in Table 4.5. The application fee is NEITHER refundable (except for condition in note above Table 4.3) NOR transferable. Payments have to be made online by using either net banking / debit card / credit card / wallet. As per the prevailing norms, additional online transaction charges or bank charges may be applicable. These charges will be specified on the payment portal.

Table 4.5 Details of Application Fee for GATE 2022 (Per Subject Paper)

For Examination Centres in India	Regular Period (30th August to 24th Sept. 2021)	During the Extended Period (25th Sep. to 1st Oct. 2021)
Female candidates (per paper)	**₹ 750**	**₹ 1250**
SC / ST / PwD* category candidates (per paper)	**₹ 750**	**₹ 1250**
All other candidates (per paper)	**₹ 1500**	**₹ 2000**

Note: The application fee mentioned above DOES NOT INCLUDE service charges, processing fees and any other charges that the banks may levy.

*PwD means Persons with Disability.

4.4.2 GATE Online Application Process

GATE 2022 (https://gate.iitkgp.ac.in) provides an online interface to the candidate for interacting with the GATE administration. With this interface, a candidate can:

•Apply for the examination.

•Upload photograph, signature and other documents and category certificate (SC / ST / PwD) and / or Dyslexic certificate as applicable.

•Pay the application fee through any of the electronic payment modes.

•Check the Status of the application form: Received, under scrutiny, Accepted, Defect status, Status after rectification, rejected with valid reasons, Admit Card ready for download, etc.

•Download Admit Card.

•View your answers, marks and GATE score.

•Download GATE scorecard.

Registration: A candidate must first register by providing Full Name (as per the valid photo ID, which candidate MUST bring in original while appearing for GATE 2022 examination at the examination centre), a valid e-mail address, mobile number and by choosing a password. All communications from the GATE Offices will be sent to this e-mail address (ONLY ONE PERSON CAN REGISTER WITH ONE e-mail ADDRESS) and / or mobile number. Give the personal mobile number and e-mail address, because most of the communication will be through e-mail and/or SMS.

Enrolment ID: Each registered candidate will be provided with an Enrolment ID. Upon registration, an e-mail containing the Enrolment ID will be sent to the candidate. This Enrolment ID will be the reference ID for all future communication until the examination gets over.

Password: The candidate has to choose a password during Enrolment. This password must be remembered along with the Enrolment ID to login in to your account. It is strongly recommended to choose a password that cannot be guessed easily (it should not be the candidate's name, date of birth, or some easily identifiable string of numbers or letters like 12345 or abcd). Length of the password should be 8-15 characters. Keep your password information safe, secure and confidential.

4.4.3 Filling in GATE 2022 Application

After due registration, GATE 2022 application must be filled and submitted ONLINE only.

Candidates are discouraged from making application through a third person. If someone else (friend or Internet café person) is filling the application on behalf of the candidate, the candidate must ensure that the data submitted are correct. Based on the earlier experience, submission through a third person is highly discouraged to ensure an error-free application.

i) Data Requirement for Filling the Application Form: The following data will be required while filling the online application form:

•Personal information (name, date of birth, personal mobile number, parents' name, parents' mobile number, etc.). Please note that the name of the candidate in the application form must be exactly the same as that in the valid photo ID, which the candidate MUST produce in original while appearing for GATE 2022 examination at the centre. GATE 2022 scorecard will be issued as per the name entered in the application form. Prefix/title such as Mr/Shri/Dr/Mrs/Smt/Prof/Capt/Maj/Lt/Col., etc. MUST NOT be used before name.

•Address for Communication (including PIN code)

•Eligibility degree details

•College name and address with PIN code

•GATE paper(s) (subject)

•Choice(s) of GATE examination cities

•High quality image of candidate's photograph conforming to the requirements specified

•Good quality image of candidate's signature conforming to the requirements specified

•Scanned copy of valid photo Identity Document (ID) (The same ID, in original, MUST be carried to the examination hall)

•Scanned copy of Category (SC / ST) certificate (if applicable) in pdf format

•Scanned copy of PwD Certificate (if applicable) in pdf format

•Scanned copy of Dyslexic Certificate (if applicable) in pdf format

•Net-banking / debit card/credit card / wallet details for fee payment

ii) Application Filling: The GATE 2022 website allows you to enter the data, save partially filled form, logout, and resume filling the form by logging in again. The online application process is self-explanatory and user-friendly. Additional help information required in filling various fields in the will also be made available.

Before proceeding to payment, the candidate is advised to view the filled-in application form by clicking "Save and View Application" button. Please check carefully for any errors in the data entered in the application form. Once the candidate clicks "Submit and Proceed to Payment" button, NO further changes to the application can be made. For online payment, follow the instructions given in Section 4.4.8 for payment options.

iii) Declaration: Before submitting the online application form, a candidate MUST read and accept the following declaration statement:

I confirm that I fulfil the eligibility criteria to appear for the Graduate Aptitude Test in Engineering (GATE 2022) examination and I, myself have filled up the entire online application form. I have fully understood each and every point in the form and filled up the details accordingly. I agree to strictly comply with the code of conduct for GATE 2022 examination as detailed in Appendix B of the Information Brochure. I confirm that the information provided by me in this form is correct in all respect. I also confirm that I am NOT filling more than ONE form for myself.

If any of the information provided by me is found to be incorrect at a later time, my candidature for GATE 2022 will be cancelled. This cancellation of my candidature can happen either before, during or after the examination, including the time after generation of my GATE 2022 score card, if any.

I also understand that GATE is NOT an admission ensuring examination, and qualifying in GATE examination does NOT guarantee admission / scholarship / job. GATE 2022 committee is NOT liable for any legal obligations related to admission / job.

I shall be liable for legal action for providing any type of false information. GATE 2022 committee's decision will be final and legally binding on me.

iv) Problems in Login: In case of forgotten user ID or password, follow the instructions on the GATE 2022 website to retrieve them.

4.4.4 Identity Proof

Candidates have to specify ANY ONE of the following valid photo Identity Documents (IDs) during the online application process and enter the document number specified: **Aadhaar-UID (preferable)**, Passport, PAN Card, Voter ID or Driving License. On the examination day, the candidate must bring the original ID proof along with the GATE 2022 Admit Card. Candidates will NOT be permitted to take the examination, in case the admit card and the same valid original photo identification document are NOT presented at the examination.

For international candidates, ONLY a valid Passport / Government issued ID / Driving License will be accepted as the recognized identification document.

4.4.5 PwD Candidates and Scribe Related Guidelines

GATE 2022 will follow the guidelines as per the government regulations (**Appendix A**).

Refer: https://gate.iitkgp.ac.in/assets/2022/PWD_Guidelines.pdf

A Person with benchmark Disability (PwD) / Dyslexic candidate has the option of availing scribe assistance during the GATE 2022 examination. The option exercised by the candidates in this regard should be done during the application stage. PwD / Dyslexic candidates can either arrange their own scribe or request GATE authority to arrange for a panel of scribes. The assistance that the Scribe can render to the candidate is limited to ONLY reading the instructions and test paper displayed on the computer screen verbatim and in mouse-clicks, if the candidate is not able to do so.

- The Scribe shall NOT translate/interpret/emphasize the Test Paper Contents to the Candidate.

i) Scribes arranged by Candidates:

The Scribe MUST NOT be a candidate for a test paper in GATE 2022. According to the GoI (Government of India) guidelines, in case the candidates have opted to bring their Scribe, then the qualification of the Scribe should be one step below the qualification of the candidates taking the examination.

- If PwD / Dyslexic candidate have opted for their own scribe but they do not bring their own Scribe then it will not be possible to arrange a new Scribe.
- NO honorarium will be paid to the scribe arranged by the PwD / Dyslexic candidate.

ii) Scribes arranged by GATE:

•GATE Scribes will be used for those PwD / Dyslexic candidates who have a priori opted for GATE Scribes.

•The qualification of the Scribe arranged by GATE will NOT be more than the minimum eligibility criteria of GATE. However, the qualification of the Scribe will be matriculation (10^{th}) or above.

•If there are Y candidates who require scribe, it will be ensured that a panel of Y+1 scribes are available at the exam centre so that every candidate can have an alternative scribe to choose for the services. A PwD / Dyslexic (similar learning disabilities) candidate who has been allowed to use a scribe has to choose from this panel. Candidates will NOT be permitted to bring their own scribe, if they have already opted for scribes to be arranged by GATE.

iii) Assistive Devices: PwD candidates, if required, can use assistive devices like Abacus, Braille slate, Wheel chair, etc. PwD candidates desiring to make use of these devices have to arrange them, on their own and bring along with them, to the examination. GATE is not in a position to provide any of these assistive devices. However, since GATE 2022 is a Computer Based Test, candidate will be given an option to view the content on the computer screen in a magnified font (Step 1 magnification: approximately 1.25**x**, and Step 2 magnification: approximately 1.5**x**).

PwD Candidates are permitted to visit the Exam Centre a day before the examination to see and get familiarized with the arrangements.

iv) Compensatory time: Candidates with Scribe can avail a compensatory time of one additional hour (20 minutes per hour of examination) at a stretch for the three-hour GATE examination. As per GATE guidelines, PwD / Dyslexic (similar learning disabilities) candidates with Scribes are eligible for a compensatory time of 60 minutes. This compensatory time of 60 minutes will be provided automatically, which needs to be checked in the server and candidate's console. However, PwD candidates, with certain benchmark disabilities (that limits the speed of writing) who do not want to avail the scribe assistance, but at the same time request for compensatory time during the time of application, may be considered for an extra time of one hour**. On-spot request for any compensatory time at the examination hall will NOT be entertained.**

4.4.6 Supporting Documents

(i) Photo ID

Candidates MUST upload PDF file of any one of the following valid photo identity (ID): Aadhaar-UID (preferable), Passport, PAN Card, Voter ID and Driving License.

For international candidates, ONLY a valid Passport / Government issued ID / Driving License will be accepted as the recognized identification document.

The candidates who do not possess any of these identity cards, may please obtain any one of them before making the application. Candidate MUST produce the SAME original valid photo ID proof during the examination for verification purpose. In absence of the SAME original valid photo ID proof, candidate will NOT be allowed to appear for GATE 2022 examination.

(ii) Category (SC / ST) Certificate

Candidates who belong to SC or ST category have to upload a valid documentary proof (for getting the concession in application fee). Certificate issued ONLY by the authorized officials will be valid (refer to **Appendix A**, for a list of Authorities Empowered to Issue SC / ST Certificate). Necessary legal actions will be initiated for any wrongdoing and misinformation. The same document is required to be submitted to the admitting institution which may admit student using GATE score at the time of admission. The onus of verifying SC / ST certificate lies with the admitting institute. The GATE committee will NOT be responsible for any incorrect declaration in this regard.

NOTE: OBC-NCL and EWS candidates are NOT required to submit / upload any category certificate while filling the online application form.

(iii) Person with Disability (PwD) Certificate

In order to avail the application fee concession under the Person with Disability (PwD) category, the candidates should attach a **recently** obtained and proper PwD certificate issued by the competent authority. Benefit would be given to those who have benchmark disability i.e. not less than 40% impairment irrespective of the type of disability. The same document is required to be submitted to the admitting institution at the time of admission. The onus of verifying PwD certificate lies with the admitting institute. The GATE committee will NOT be responsible for any incorrect declaration of the PwD status of candidates.

Those PwD candidates who have physical limitation to take examination, including that of speed, may request during the application time for availing the services of a scribe. A scribe will be arranged by the GATE authorities.

(iv) Certificate of Dyslexia

To avail the services of a scribe, the dyslexic candidates should attach a proper dyslexic certificate issued by any authorized Dyslexia Association (refer to **Appendix A**, for Authorities Empowered to Issue Certificate of Dyslexia). The scribe will be provided by the GATE authorities. The same document is required to be submitted to the admitting institution at the time of admission. The onus of verifying dyslexic certificate lies with the admitting institute. The GATE committee will not be responsible for any incorrect declaration of the dyslexic status of candidates.

4.4.7 Photograph and Signature Requirements

The GATE 2022 application requires that your photograph and signature are to be uploaded electronically. Uploading photograph and signature that does not meet the specifications may eventually result in the disqualification of the application without any refund of the application fee.

Photograph Requirements:

- Please upload only good quality (not blurred) photograph as per following guidelines. The GATE 2022 admit card and scorecard will be printed with the photograph that you have submitted.
- The photograph MUST match with your appearance on the day of the examination.

•A passport size (3.5 cm Width × 4.5 cm Height) photograph of the face of the candidate is required for the application form.

•The face of the candidate must cover 60% - 70% of the above mentioned size of the photograph.

•The photograph must be recent, in COLOUR with WHITE background. Photographs taken using a mobile phone and other self-composed portraits may result in rejection of the application.

•Face in the photo MUST NOT be covered with any foreign objects (except spectacles with power). Sunglasses, Caps, Hats, Coloured glasses etc. are NOT allowed.

•Both the ears MUST be visible on the photo.

•Photo MUST contain ONLY candidate's face. NO objects/persons in the background are allowed.

•Upload the image of your photo in JPEG / JPG format of size with aspect ratio, minimum aspect ratio = 0.66; maximum aspect ratio = 0.89. After cropping to the mentioned size, face must cover 60-70% of the image.

• Maximum size for photo can be 480×640 in pixels and minimum pixel resolution 240x320. File size MUST be minimum of 20 kB and maximum of 200 kB.

•Background of the photograph must be WHITE in *colour*.

•The photograph MUST have a full-face view looking into the camera directly.

•The main features of the face must not be covered by hair of the head, any cloth or any shadow. Forehead, eyes, nose, ears and chin should be clearly visible.

•If the candidate normally wears spectacles, a photograph with glare on glasses is NOT acceptable in the photo. While the candidate may wear spectacles for the photo shoot, if the glare cannot be avoided, then the spectacles MUST be removed.

•Photographs which are not adhering to above criteria will lead to rejection of your GATE application, WITHOUT any refund of the application fee.

•Table 4.6 shows the samples of acceptable good quality photographs and poor quality unacceptable photographs.

Table 4.6 Sample Photographs

A: Sample Photographs: Acceptable			
			
B: Sample Photographs: Not Acceptable			
 Smaller in size (Not matching with a specified size of 35 mm width x 45 mm height)	 Wearing coloured glasses or sunglasses	 Shadow on face	
 Improper background and side view	 Not facing the camera	 Photo taken in dark background	
 Distorted Face	 Face covered with Mask	 Blurred image	

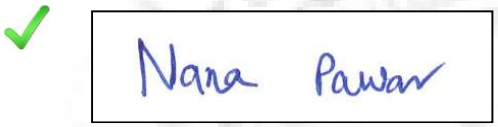
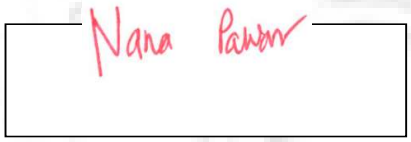
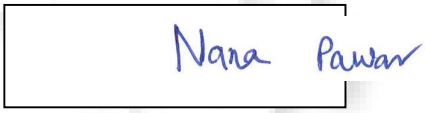
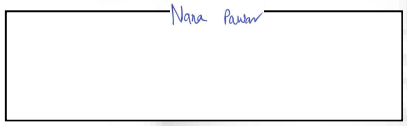
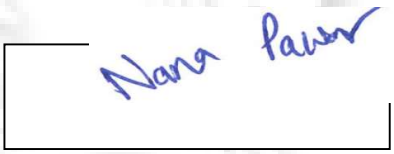
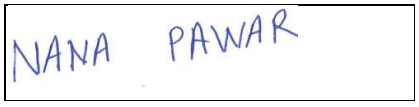
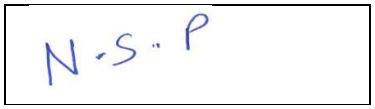
Signature Specifications:

Upload the image of your clear signature in JPEG / JPG format of size with aspect ratio, height: width = 1.0 : A, where, value of A can be between 3.25 to 3.75. After cropping to the mentioned size, area of signature must cover 70-80% of the image.

•Sign with black or dark blue colour ink only.

•File size MUST be within 5 kB (minimum) to 200 kB (maximum).

Table 4.7 Sample Signatures

Acceptable signatures	
	
Unacceptable signatures	
Signature in other than blue or black ink 	Signature outside the rectangular box 
Signature in smaller in size 	
Signature in dark background 	Signature in typing Nana Power
Signature in CAPITAL 	Signature in initial 

•The signature by any other person or in any other colour (other than **black** and **blue**) will NOT be accepted.

•Get the digital image of the rectangular box (with your signature inside) scanned by using a professional scanner. Crop it to the border of the box. Table 4.7 shows sample signatures which are acceptable and unacceptable.

•To avoid signature with a dark background, **do not take photograph with mobile phone**.

•Only JPEG / JPG image format will be accepted.

•The maximum image size for the signature can be 160×560 in pixels.

•The minimum image size for the signature should be 80×280 in pixels.

•The signature must be signed only by the applicant and not by any other person.

•If the applicant's signature, at the time of examination, does NOT match the signature on the Admit Card, the applicant will be disqualified.

4.4.8 Application Fee Payment Options

Details of the application fee are given in Table 4.5. From the GATE 2022 application portal, the candidate will be redirected to the payment gateway, which provides the payment options. The fee can be paid with net-banking / debit / credit card / wallet / UPI.

The fee amount and bank charges will be shown to the candidate and he/she will have to confirm and pay. Once the payment is successful, he/she will be redirected back to the GATE 2022 application portal, from where the candidate will be able to download the pdf copy of the submitted application form by clicking "Download Application Form" button.

If the candidate has any difficulty (due to internet connection or power failure problems, for example), and he/she is not sure whether the payment has been processed or not, then the candidate should check the status of transaction from their bank account and also login back to GATE 2022 application portal after some time and check the status of the payment.

If the payment was received by GATE, you can continue the process of printing the application form. If the payment is not received by GATE 2022, you may initiate a fresh payment.

In case, any fee amount has been debited (deducted) from your bank account, but not received any acknowledgement for fee payment from GATE 2022, then the money will be credited back to your account. However, this may take a week or more.

Any multiple payments received on behalf of GATE 2022 from your account with respect to one application, will automatically be returned (credited) to the same bank account. However, this may take a week or more. In such a situation, the candidate needs to initiate fresh payment without waiting for the refund of money paid, in order to complete the application submission process within the deadline.

Before submitting the GATE 2022 Application Form, the candidate MUST ensure that all the details and all the necessary supporting documents are filled/uploaded and there is NO ERROR in that process. An application once submitted **CANNOT** be changed/rectified. As a checklist the candidate MUST verify that he/she has filled in and uploaded the following information, whichever is applicable:

•Personal information (name, date of birth, personal mobile number, parent's/guardian's name, parent's/guardian's mobile number, etc.).

•Address for Communication (including PIN code).

•Eligibility degree details (Roll No / Registration No, College address, PIN code of college).

•Good quality image of a recent photograph conforming to the requirements specified.

•Good quality image of signature conforming to the requirements specified.

•Details and good quality scanned copy of the same valid photo ID Proof that will be carried to the examination hall.

•Category certificate (SC / ST / PwD) in case a concession in application fee is claimed.

Important: It is essential that the candidate fills-in all the details in GATE 2022 online application form without ANY ERROR. The application is liable to be REJECTED if there is any error. GATE committee is NOT responsible for the rejection of any application due to such error(s).

4.5 Application Scrutiny and Rectification

All the applications submitted for GATE 2022 examination will be scrutinized for the accuracy of the data, which include uploaded supporting documents, clarity of the photograph and signature. If everything is found to be in order, the application will be accepted. Otherwise, defects in the application will be marked and intimated to the candidate for rectification, which needs to be carried out within a stipulated given time. The status of the application and defects identified in the application will be intimated to the candidates by an e-mail and/or SMS, which the candidate has provided while filling the application form. The current status of an application will be updated after its receipt and scrutiny by the respective zonal GATE offices. The status of the candidate's application can be checked anytime by logging into your GATE 2022 account.

Candidates should act **quickly to rectify** the defects in the application and update it before the stipulated deadline. Failing to rectify the defects within the stipulated time can lead to the rejection of the application and NO further communication will be entertained in this regard.

4.6 Admit Card

Admit Card can ONLY be downloaded from the GATE 2022 website from 3rd January 2022. Admit Cards will NOT be sent by post or as an e-mail attachment.

Candidates must bring a print-out of the downloaded Admit Card on A4 sized paper to the Examination for the verification along with the original and valid photo Identity Document (NO photocopy / scanned copy / NOT an expired document), which was specified during the filling up of

the online application (for example: Aadhaar-UID, Passport, PAN card, Voter ID and Driving License).

The Admit Card is valid IF and ONLY IF the candidate's photograph and signature images are clear and legible. The photograph on the Admit Card and that in the valid photo identity document should match with the appearance of the candidate on the day of examination. To ensure this, print the Admit Card on an A4 sized paper using a **laser printer**, preferably in colour. Both, the GATE 2022 Admit Card and Original ID proof are essential for entry into the examination hall.

5. GATE 2022 Examination Related Information

GATE 2022 examination will be conducted for 29 papers (subjects) as listed in Table 4.2. A candidate can appear for one or two (as per combinations given in Table 4.3) of the 29 GATE papers. The examination for all the papers will be conducted in an ONLINE Computer Based Test (CBT) mode where the candidates will be shown the questions on a computer screen.

A Virtual Scientific Calculator will be available on the computer screen during the examination. Candidates have to use the same during the examination. Personal calculators, any type of watches, wallets, mobile phones or any electronic / communication devices are NOT allowed inside the examination hall. Candidates must NOT bring any charts/tables/papers into the examination hall. GATE officials will NOT be responsible for the safe-keep of the candidates' personal belongings.

A scribble pad will be provided to the candidates for rough work. The candidates have to write their name and registration number on the scribble pad before they start using it. The candidate can possess ONLY one scribble pad at any point of time. Before taking the second scribble pad, if required, the first scribble pad MUST be returned to the invigilator. The scribble pad in the candidate's possession must be returned to the invigilator at the end of the examination.

Syllabus for each of the papers (Appendix C), previous years GATE (model) question papers, and mock examination links along with virtual scientific calculator will be available on GATE 2022 website: https://gate.iitkgp.ac.in/

Note: Zonal GATE offices (IITs and IISc) NEVER sell or advertise any GATE examination papers or syllabus. Candidates MUST be aware about frauds in the market/fake emails/fake SMS related to this aspect. Any individual/organization claiming to sell /distribute GATE papers in the name of IITs and IISc will be subjected to appropriate legal actions.

5.1 Examination Duration

All the papers of the GATE 2022 examination will be of 3 hours duration and they consist of 65 questions for a total of 100 marks. Since the examination is an ONLINE computer based test (CBT), at the end of the stipulated time (3-hours), the computer screen will automatically close the examination inhibiting any further action.

Candidates will be permitted to occupy their allotted seats 40 minutes before the scheduled start of the examination. Candidates can login and start reading the instructions 20 minutes before the start of examination. The late login time (if any) recorded by the computer system MUST NOT be beyond 30 minutes from the actual starting time of the examination. Under NO circumstances, will a candidate be permitted to login after 30 minutes from the actual examination starting time. Candidates will NOT be permitted to leave the examination hall before the end of the examination.

5.2 GATE 2022 Question Papers

5.2.1 Pattern of Questions

GATE 2022 may contain questions of THREE different types in all the papers:

(i) Multiple Choice Questions (MCQ) carry 1 or 2 marks each, in all the papers and sections. These questions are objective in nature, and each will have choice of four answers, out of which ONLY ONE choice is correct.

Negative Marking for Wrong Answers: For a wrong answer chosen in a MCQ, there will be negative marking. For 1-mark MCQ, 1/3 mark will be deducted for a wrong answer. Likewise, for 2-mark MCQ, 2/3 mark will be deducted for a wrong answer.

Example of MCQ :

Which Institute is organising GATE 2022 examination ?

(A)IISc Bangalore (B) IIT Kharagpur (C) IIT Delhi (D) IIT Madras.

Here, correct answer is (B) only. Candidate will get full marks only if this answer is selected. The candidates will be given NEGATIVE marks for choosing any other option as their answer.

(ii) Multiple Select Questions (MSQ) carrying 1 or 2 marks each in all the papers and sections. These questions are objective in nature, and each will have choice of four answers, out of which ONE or MORE than ONE choice(s) is / are correct.

Note: *There is NO negative marking for a wrong answer in MSQ questions. However, there is NO partial credit for choosing partially correct combinations of choices or any single wrong choice.*

Example of MSQ :

Which of the following is / are state(s) in India ?

(A)Maharashtra (B) Gujarat (C) Mumbai (D) Goa.

Here, the correct answer is the combination of (A), (B) and (D). Candidates will get full marks if and only if this combination is selected. There are NO partial marks in this type of question. The candidates will NOT get any marks for choosing any other option / combination as their answer.

(iii) Numerical Answer Type (NAT) Questions carry 1 or 2 marks each in most of the papers and sections. For these questions, the answer is a signed real number, which needs to be entered by the candidate using the virtual numeric keypad on the monitor (keyboard of the computer will be disabled). No choices will be shown for these types of questions. The answer can be a number such as 10 or -10 (an integer only). The answer may be in decimals as well, for example, 10.1 (one decimal) or 10.01 (two decimals) or -10.001 (three decimals). These questions will be mentioned with, up to which decimal places, the candidates need to present the answer. Also, for some NAT type problems

an appropriate range will be considered while evaluating these questions so that the candidate is not unduly penalized due to the usual round-off errors. Candidates are advised to do the rounding off at the end of the calculation (not in between steps). Wherever required and possible, it is better to give NAT answer up to a maximum of three decimal places.

Example of NAT : If the wire diameter of a compressive helical spring is increased by 2%, the change in spring stiffness (in %) is _(correct to two decimal places).

Note: There is NO negative marking for a wrong answer in NAT questions.

Also, there is NO partial credit in NAT questions.

5.2.2 Marks Distribution

In all the papers, there will be a total of 65 questions carrying 100 marks, out of which 10 questions carrying a total of 15 marks will be on General Aptitude (GA), which is intended to test typically the Language and Analytical Skills.

In the papers bearing the codes AE, AG, BM, BT, CE, CH, CS, EC, EE, ES, GE, IN, ME, MN, MT, NM, PE, PI, TF and XE, the Engineering Mathematics will carry around 15% of the total marks, the General Aptitude section will carry 15% of the total marks and the remaining around 70% of the total marks is devoted to the subject of the paper.

In the papers bearing the codes AR, CY, EY, GG, MA, PH, ST, XH and XL, the General Aptitude section will carry 15% of the total marks and the remaining 85% of the total marks is devoted to the subject of the paper.

5.2.3 Design of Questions

The questions in a paper may be designed to test the following abilities:

(i)Recall: These are based on facts, principles, formulae or laws in the discipline of the paper. The candidate is expected to be able to obtain the answer either from his/her memory of the subject or at most from a one-line computation.

Example:

Q. During machining, maximum heat is produced

(A) in flank face(B) in rake face

(C) in shear zone(D) due to friction between chip and tool

(ii)Comprehension: These questions will test the candidate's understanding of the basics of his/her field, by requiring him/her to draw simple conclusions from fundamental ideas.

Example:

Q. A DC motor requires a starter in order to

(A) develop a starting torque(B) compensate for auxiliary field ampere turns

(C) limit armature current at starting(D) provide regenerative braking

(iii) Application: In these questions, the candidate is expected to apply his/her knowledge either through computation or by logical reasoning.

Example:

Q. The sequent depth ratio of a hydraulic jump in a rectangular channel is 16.48. The Froude number at the beginning of the jump is:

(A) 5.0 (B) 8.0 (C) 10.0 (D) 12.0

The above questions may be a mix of single standalone statement/phrase/data type questions, combination of option codes type questions or match items type questions.

(iv) Analysis and Synthesis: In these questions, the candidate is presented with data, diagrams, images, etc. that require analysis before a question can be answered. A Synthesis question might require the candidate to compare two or more pieces of information. Questions in this category could, for example, involve candidates in recognizing unstated assumptions, or separating useful information from irrelevant information.

5.3 Marking Scheme – Distribution of Marks and Questions

5.3.1 General Aptitude (GA) Questions

In all papers, GA questions carry a total of 15 marks. The GA section includes 5 questions carrying 1-mark each (sub-total 5 marks) and 5 questions carrying 2-marks each (sub-total 10 marks).

5.3.2 Question Papers other than AR, GE, GG, XE, XH and XL

These papers would contain 25 questions carrying 1-mark each (sub-total 25 marks) and 30 questions carrying 2-marks each (sub-total 60 marks) consisting of some MCQ type questions, while the remaining may be MSQ and / or NAT questions.

5.3.3 AR (Architecture and Planning) Paper

Apart from the General Aptitude (GA) section, the question paper consists of two parts: Part A (60 marks) and Part B (25 marks). Part A is compulsory for all the candidates. Part B contains two parts: Part B1 (Architecture) and Part B2 (Planning). Candidates will have to attempt questions in Part A and questions in either Part B1 or Part B2 of Part B. The choice of Part B1 OR Part B2 can be made during examination.

Part A consists of 39 questions carrying a total of 60 marks: 18 questions carrying 1-mark each (sub-total 18 marks) and 21 questions carrying 2-marks each (sub-total 42 marks). Some are MCQ type questions, while the remaining may be MSQ and / or NAT questions. Either section of Part B [Part B1 (Architecture) and Part B2 (Planning)] consists of 16 questions carrying a total of 25 marks: 7 questions carrying 1-mark each (sub-total 7 marks) and 9 questions carrying 2-marks each (sub-total 18 marks). Some are MCQ type questions, while the remaining may be MSQ and / or NAT questions.

5.3.4 GE (Geomatics Engineering) Paper

Apart from the General Aptitude (GA) section, the question paper consists of two parts: Part A (55 marks) and Part B (30 marks). Part A is compulsory for all the candidates. Part B contains two sections: Section I and Section II. Candidates will have to attempt questions in Part A and questions in either Section I or Section II of Part B. The choice of Section I OR Section II of Part B can be made during examination.

Part A consists of 36 questions carrying a total of 55 marks: 17 questions carrying 1-mark each (sub-total 17 marks) and 19 questions carrying 2-marks each (sub-total 38 marks). Some are MCQ type questions, while the remaining may be MSQ and / or NAT questions. Either section of Part B [Section

I or Section II) consists of 19 questions carrying a total of 30 marks: 8 questions carrying 1-mark each (sub-total 8 marks) and 11 questions carrying 2-marks each (sub-total 22 marks). Some are MCQ type questions, while the remaining may be MSQ and / or NAT questions.

5.3.5 GG (Geology and Geophysics) Paper

Apart from the General Aptitude (GA) section, the GG question paper consists of two parts: Part A and Part B. Part A is compulsory for all the candidates. Part B contains two sections: Section 1 (Geology) and Section 2 (Geophysics). Candidates will have to attempt questions in Part A and questions in either Section 1 or Section 2 of Part B. The choice of Section 1 OR Section 2 of Part B has to be made **at the time of filling online application form**. At the examination hall, candidate cannot request for change of section.

Part A consists of 16 questions carrying a total of 25 marks: 7 questions carrying 1-mark each (sub-total 7 marks) and 9 questions carrying 2-marks each (sub-total 18 marks). Some are MCQ type questions, while the remaining may be MSQ and / or NAT questions. Either section of Part B (Section 1: Geology and Section 2: Geophysics) consists of 39 questions carrying a total of 60 marks: 18 questions carrying 1-mark each (sub-total 18 marks) and 21 questions carrying 2-marks each (sub-total 42 marks). Some are MCQ type questions, while the remaining may be MSQ and / or NAT questions.

5.3.6 XE Paper (Engineering Sciences)

A candidate appearing in the XE paper has to answer the following:

- GA – General Aptitude carrying a total of 15 marks.

Section A – Engineering Mathematics (Compulsory): This section contains 11 questions carrying a total of 15 marks: 7 questions carrying 1-mark each (sub-total 7 marks), and 4 questions carrying 2-marks each (sub-total 8 marks). Some are MCQ type questions, while the remaining may be MSQ and / or NAT questions.

Any two of XE Sections B to H: The choice of two sections from B to H can be made during the examination after viewing the questions. Only TWO optional sections can be answered at a time. A candidate wishing to change midway of the examination to another optional section must first choose to deselect one of the previously chosen optional sections (B to H). Each of the optional sections of the XE paper (Sections B through H) contains 22 questions carrying a total of 35 marks: 9 questions carrying 1-mark each (sub-total 9 marks) and 13 questions carrying 2-marks each (sub-total 26 marks). Some are MCQ type questions, while the remaining may be MSQ and / or NAT questions.

5.3.7 XH Paper (Humanities and Social Sciences)

A candidate appearing in the XH paper has to answer the following:

- GA – General Aptitude carrying a total of 15 marks

Section B1 – Reasoning and Comprehension (Compulsory): This section contains 15 questions carrying a total of 25 marks: 7 questions carrying 1-mark each (sub-total 7 marks) and 9 questions

carrying 2-marks each (sub-total 18 marks). Some are MCQ type questions, while the remaining may be MSQ and / or NAT questions.

Any ONE of XH Sections C1 to C6: The ONE choice of section from C1 to C6 has to be made **at the time of filling online application form**. Candidate cannot request for change of section at the examination hall. Each of the optional sections of the XH paper (Sections C1 through C6) contains 39 questions carrying a total of 60 marks: 18 questions carrying 1-mark each (sub-total 18 marks) and 21 questions carrying 2-marks each (sub-total 42 marks). Some are MCQ type questions, while the remaining may be MSQ and / or NAT questions.

5.3.8 XL Paper (Life Sciences)

A candidate appearing in the XL paper has to answer the following:

- GA – General Aptitude carrying a total of 15 marks.

Section P– Chemistry (Compulsory): This section contains 17 questions carrying a total of 25 marks: 9 questions carrying 1-mark each (sub-total 9 marks) and 8 questions carrying 2-marks each (sub-total 16 marks). Some are MCQ type questions, while the remaining may be MSQ and / or NAT questions.

Any two of XL Sections Q to U: The choice of two sections from Q to U can be made during the examination after viewing the questions. Only TWO optional sections can be answered at a time. A candidate wishing to change midway of the examination to another optional section must first choose to deselect one of the previously chosen optional sections (Q to U). Each of the optional sections of the XL paper (Sections Q through U) contains 19 questions carrying a total of 30 marks: 8 questions carrying 1-mark each (sub-total 8 marks) and 11 questions carrying 2-marks each (sub-total 22 marks). Some are MCQ type questions, while the remaining may be MSQ and / or NAT questions.

6. Post-Examination Related Information

Post examination events are as follows:

1. After the GATE 2022 examinations, candidates' responses will be available in their account at GATE 2022 website, which can be downloaded.
2. Answer keys for various GATE 2022 papers will be displayed in GATE 2022 website.
3. Candidates may submit their contests on the answer keys provided for a very limited time period against a payment.
4. Evaluation of examination papers will be finalized and GATE results (Score) will be announced.
5. Qualified candidates can download score card from their accounts at GATE 2022 website.

6.1. GATE Score

After the evaluation of the answers, the actual (raw) marks obtained by a candidate will be considered for computing the GATE Score. For multi-session papers (subjects), raw marks obtained by the candidates in different sessions will be converted to Normalized marks for that particular subject. Thus, raw marks (for single session papers) or normalized marks (for multi-session papers) will be used for computing the GATE Score, based on the qualifying marks.

6.1.1 Calculation of Normalized Marks for Multi-Session Papers

In GATE 2022 examination, some papers may be conducted in multi-sessions. Hence, for these papers, a suitable normalization is applied to take into account any variation in the difficulty levels of the question papers across different sessions. The normalization is done based on the fundamental assumption that "in all multi-session GATE papers, the distribution of abilities of candidates is the same across all the sessions". This assumption is justified since the number of candidates appearing in multi-session papers in GATE 2022 is large and the procedure for allocation of session to candidates is random. Further, it is also ensured that for the same multi-session paper, the number of candidates allotted in each session is of the same order of magnitude.

Based on the above, and considering various normalization methods, the committee arrived at the following formula for calculating the normalized marks for the multi-session papers.

Normalization mark of j^{th} candidate in the i^{th} session $\widehat{M}_{ij}$ is given by

$$\widehat{M}_{ij} = \frac{\bar{M}_t^g - M_q^g}{\bar{M}_{ti} - M_{iq}}\left(M_{ij} - M_{iq}\right) + M_q^g$$

where

M_{ij}: is the actual marks obtained by the j^{th} candidate in i^{th} session

$\bar{M}_t^g$: is the average marks of the top 0.1% of the candidates considering all sessions

M_q^g: is the sum of mean and standard deviation marks of the candidates in the paper considering all sessions

$\bar{M}_{ti}$: is the average marks of the top 0.1% of the candidates in the i^{th} session

M_{iq}: is the sum of the mean marks and standard deviation of the i^{th} session.

6.1.2 Calculation of GATE Score for All Papers

For all papers for which there is only one session, actual marks obtained by the candidates will be used for calculating the GATE 2022 Score. For papers in multi-sessions, normalized marks will be calculated corresponding to the raw marks obtained by a candidate and the GATE 2022 Score will be calculated based on the normalized marks.

The GATE 2022 score will be computed using the formula given below.

where

$$GATE\ Score = S_q + \left(S_t - S_q\right)\frac{\left(M - M_q\right)}{\left(\bar{M}_t - M_q\right)}$$

$\boldsymbol{M}$: marks obtained by the candidate (actual marks for single session papers and normalized marks for multi-session papers)

$\boldsymbol{M_q}$: is the qualifying marks for general category candidate in the paper

$\bar{\boldsymbol{M}}_{\boldsymbol{t}}$: is the mean of marks of top 0.1% or top 10 (whichever is larger) of the candidates who appeared in the paper (in case of multi-session papers including all sessions)

$\boldsymbol{S_q}$: 350, is the score assigned to $\boldsymbol{M_q}$

$\boldsymbol{S_t}$: 900, is the score assigned to $\bar{\boldsymbol{M}}_{\boldsymbol{t}}$

In the GATE 2022 the qualifying marks ($\boldsymbol{M_q}$) for general category student in each subject will be 25 marks (out of 100) or **μ + σ,** whichever is larger. Here **μ** is the mean and **σ** is the standard deviation of marks of all the candidates who appeared in the paper.

After the declaration of results, GATE Scorecards can be downloaded by the GATE qualified candidates ONLY.

The GATE 2022 Committee has the authority to decide the qualifying mark/score for each GATE paper. In case of any claim or dispute with respect to GATE 2022 examination or score, the Courts and Tribunals in Kolkata alone will have the exclusive jurisdiction to entertain and settle them.

6.2. GATE 2022 Results

GATE 2022 results will be announced on 17th March 2022 and will be available on the GATE 2022 Website. GATE 2022 score is valid for THREE YEARS from the date of announcement of the results. No information on the GATE 2022 score will be available after this period.

6.3. GATE 2022 Scorecard

After the declaration of results, GATE 2022 Scorecards of the qualified candidates can be downloaded free of cost between 21st March 2022 to 31st May 2022 from the GATE 2022 website. It is highly recommended that a softcopy of the scorecard is safely stored by the candidate for all the future uses.

In case, GATE qualified candidates require the soft copy of their GATE Scorecard after 31st May 2022 and till 31st December 2022, they MUST pay a fee of ₹500 (Rupees five hundred only) for obtaining the same. From 1st January 2023 onwards, NO scorecard will be issued by GATE authority for GATE 2022 qualified candidates.

There is NO provision for the issue of hard copies of the GATE Scorecard.

7. Frequently Asked Questions (FAQs)

7.1. Application Process

Q1. I am currently studying in 3rd year B.A./B.Com./B.Sc. Am I eligible to appear for GATE 2022?

A1. Yes, any undergraduate student currently in 3rd year or higher years of any government approved program in Engineering / Technology / Architecture / Arts / Commerce / Science is eligible to appear for GATE 2022.

Q2. I am currently studying in 3rd year B.E., but through parallel entry in the 2nd year after finishing Diploma, am I eligible to appear for GATE 2022?

A2. Yes, any undergraduate student currently in 3rd year or higher years of any government approved program in Engineering/Technology/Architecture/Arts/Commerce/Science is eligible to appear for GATE 2022.

Q3. Is there any age limit to appear for GATE 2022?

A3. NO. There is NO age limit to appear for GATE 2022.

Q4. Are there any restrictions on the number of times one can appear for GATE?

A4. NO. One can appear for the GATE examination any number of times.

Q5. Can I appear in any of the GATE 2022 papers?

A5. Although, the candidate is free to choose any of the papers [up to two from the given combinations], candidate should select paper appropriate to the discipline of qualifying degree.

Q6. How do I apply ONLINE?

A6. Refer to Section 4.4.2 given in the GATE 2022 Brochure and by visiting the website https://gate.iitkgp.ac.in

Q7. Can I use one e-mail address to fill multiple application forms?

A7. NO. One e-mail address can be used to submit only ONE application form.

Q8. Do I need to fill two forms to appear in two papers?

A8. NO. The two papers option may be selected based on the given set of combinations in a SINGLE form only.

Q9. Why should I choose THREE examination cities?

A9. The candidates will most likely be allotted a centre in the examination city of their first choice. Only in cases, where there are too many candidates opting for a certain city as their first choice, the other two choices become relevant. The candidates are required to fill their choices of cities to appear in the examination, but should remember that because of operational constraints, the GATE committee reserves the right to add a new city or remove an existing one, and allot a city that may not be any of the choices of a candidate.

Q10. What do I do, if the power / internet connection failed during the submission of application process?

A10. Please login to your account at GATE 2022 website again and continue the application process.

Q11. Does the OBC (non-creamy layer) or EWS candidates need to upload thecategory certificate?

A11. NO.

Q12. Does the SC/ST/PwD candidate need to upload the category certificate?

A11. YES, category certificate is quired to avail the concession in application fee.

Q13. How do I make the fee payment for GATE 2022 examination?

A13. The payment option will appear after filling the online application form in GATE 2022 website. The candidate can opt for any of the payment options listed over there. The additional charges such as service charges, processing fees or bank charges, have to be borne by the candidate.

Q14. How much fee should I pay to appear in Two papers of GATE 2022 examination?

A14. The fee per paper is given below, for two papers the amount of fee is twice that of a single paper.

For Examination Centres in India	Regular Period	During the Extended Period
Female candidates (per paper)	**₹ 750**	**₹ 1250**
SC / ST / PwD* category candidates (per paper)	**₹ 750**	**₹ 1250**
All other candidates (per paper)	**₹ 1500**	**₹ 2000**

Q15. What is the fee for candidates with foreign nationality?

A15. For the candidates with Foreign nationality, who wish to appear for GATE 2022 examination, the application fee **per paper** is as follows**:**

Examination Centres	Regular period	During the Extended Period
Centres in India	**₹ 1500**	**₹ 2000**

Q15. What do I do, if power/Internet connection failed during an online payment?

A15. When you can get back online, login back to GATE 2022 website and check the status of the payment. If the payment was received by GATE, you can continue the process of printing the application form. If the payment was not received by GATE 2022, you may initiate a fresh payment.

In case, any fee amount has been debited (deducted) from your bank account, but not received any acknowledgement for fee payment from GATE 2022, then the money will be credited back to your account. However, this may take a week or more.

Q16. Money has been debited from my account more than once. How do I get the money back?

A16. All multiple payments received on behalf of GATE 2022 from your account with respect to one application, will automatically be returned (credited) to the same bank account. However, this may take a week or more.

Q17. Do I have to send the print-out of the application form?

A17. NO. The print-out of the application form is NOT required to be sent to the Organising Institute (IIT Kharagpur) or any other GATE zonal offices.

Q18. When and how will I know the status of my application?

A18. You can check the status of your application by logging into GATE 2022 website time to time.

Q19. After completing the ONLINE application process and generating a PDF file, will I be able to change my application data?

A19. NO. After completing all the steps up to PDF application form generation in the ONLINE application process, you can only download the application form and CANNOT modify the data. Hence, you need to be very careful while entering the data.

Q20. I have missed to take a print-out of my ONLINE application at the end of my application process. How will I get access to it?

A20. You can login using Enrolment ID and password and take a print-out for your own reference. The print-out must not be sent to GATE Organising Institute.

Q21. If I have not uploaded photograph as per the specifications mentioned, will my application be rejected?

A21. YES, without proper photograph, the application will be REJECTED.

Q22. If I have not uploaded signature as per the specifications mentioned, will my application be rejected?

A22. YES, without proper signature, the application will be REJECTED.

Q23. Which Identity Document (ID) will be accepted in the application form?

A23. For Indian candidates, the following valid photo identification documents/cards will be accepted: Aadhaar-UID (preferable), Passport, PAN Card, Voter ID and Driving License.

Q24. Is there a relaxation in cut-off score and fee for the EWS (Economically weaker section) candidates?

A24. The application fee for EWS candidates will be same as that of General candidates, however, the qualifying mark is 90% as that of the General candidates.

Q25. What will happen if I am not able to produce EWS certificate at the time of admission/ counselling etc.?

A25. If you are not having a valid EWS certificate at the time of admission/counselling, you will be considered as General category candidate. However, GATE has nothing to do with subsequent admission or recruitment process.

Q26. Do I have to upload my EWS certificate during the application process?

A26. NO.

7.2. Admit Card

Q27. When will I receive my Admit Card?

A27. Admit Card can ONLY be downloaded from the GATE 2022 website from 3rd January 2022. Admit Cards will NOT be sent by post or as an e-mail attachment.

Q28. Is the Admit Card alone sufficient to gain entry to the examination centre?

A28. NO. Candidates MUST also bring original and valid photo Identity Document (NO photocopy/scanned copy/NOT an expired document), which was specified during filling up of the online application.

For Indian candidates, only following identification cards will be accepted: Aadhaar-UID (preferable), Passport, PAN card, Voter ID and Driving License.

Q29. Can I bring soft copy of the Admit Card (in mobile phone/tablet/laptop) to gain entry to the examination centre?

A29. NO. Hard copy (preferably printed in colour) of the Admit Card is required to gain entry to the examination centre.

7.3. GATE 2022 Examination

Q30. For how many GATE papers can I apply?

A30. A candidate can apply for ONE or TWO papers (from the given set of combinations as per Table 4.3) of the 29 papers listed in the GATE INFORMATION BROCHURE or GATE website. The choice of the appropriate paper is the responsibility of the candidate. Some guidelines in this respect are suggested below:

- The candidates are expected to appear in paper(s) [up to two as per the given set of combinations in Table 4.3] appropriate to the discipline of their qualifying degree.

- The candidates are, however, free to choose any other paper according to their admission plan, keeping in mind the eligibility criteria of the institutions in which they wish to seek admission.

Q31. If a paper is being held in more than one session, can I appear in any of the sessions of that particular paper?

A31. NO. Each candidate will be assigned to ONLY ONE of the multiple sessions of a particular paper.

Q32. After submission of application, am I permitted to change my GATE Examination Paper?

A32. YES. ONLY after the last date for application submission, a request for the change of GATE Examination Paper will be entertained against additional payment till **1st October, 2021**. Any request after this date will NOT be considered.

Q33. After submission of application, am I permitted to change my GATE Examination City?

A33. YES. ONLY after the last date for application submission, a request for the change of examination city will be entertained against additional payment till 12th November, 2021. Any request after this date will NOT be considered.

Q34. After submission of application, am I permitted to change my Category?

A34. YES. ONLY after the last date for application submission, category change request will be entertained against additional payment till 12th November, 2021. Any request after this date will NOT be considered.

Q35. Will I be provided with any white paper for rough work and calculations during the examination?

A35. Only one scribble pad at any point of time will be provided to the candidate that can be used to do the rough work. To obtain a second scribble pad, the candidate MUST return the first scribble pad. The candidates have to return any scribble pad in their possession at the end of the examination. The virtual scientific calculator will be available on the computer screen.

Q36. Am I allowed to enter the examination hall at any time during the examination?

A36. NO. Candidates MUST enter before the starting time of the examination. Delayed entry is permitted such that candidates login NOT later than 30 minutes from the starting time of the examination. NO relaxation is given under any circumstances.

Q37. In case of permitted delayed entry in the examination hall, will I get extra time corresponding to my delayed entry?

A37. NO. The candidate with permitted delayed entry will NOT get any extra time.

Q38. Am I allowed to leave the examination hall during the examination?

A38. NO. Candidates will NOT be allowed to leave the examination hall for any reason during the examination. Candidates are allowed to leave the examination hall only after the scheduled end of examination.

Q39. What items are not permitted to be brought with me inside the examination venue?

A39. Mobile phones, physical calculators, wallets, watches of any type, any electronic/communicating devices, books, papers, loose sheets, pen/pencil box/pouch and any other similar items are NOT permitted inside the examination hall.

Q40. Can I use a physical calculator during the examination?

A40. NO. During the online GATE 2022 examination, all candidates will be provided with a virtual scientific calculator which has to be used to answer the questions.

Q41. Will there be any arrangement at the examination centre for the safekeeping of my personal items such as my mobile phone?

A41. NO. Such arrangements will not be made at the examination centre. If a candidate brings personal belongings including mobile phones, they have to be kept outside the examination hall at the candidate's own risk. The GATE officials are not responsible for safe keeping of your personal items.

Q42. What happens if a physical calculator (even on an electronic watch) or a mobile phone (even in switched off mode) is found in my possession in the examination hall?

A42. Such cases are in violation of GATE 2022 code of conduct and will lead to disqualification of the candidature.

Q43. Is there a separate rank/paper for Architecture and Planning (AR) candidates in GATE 2022?

A43. NO separate scores and ranks will be provided for candidates attempting either Part B1 (Architecture) or Part B2 (Planning).

Q44. Is there a separate rank/paper for Geomatics Engineering (GE) candidates in GATE 2022?

A44. NO separate scores and ranks will be provided for candidates attempting either Part B (section I) or Part B (Section II).

Q45. Is there a separate rank/paper for Geology and Geophysics (GG) candidates in GATE 2022?

A45. Separate scores and ranks will be provided for the candidates based on the Part B section in GG paper.

For this, separate cut-off marks will be obtained as per the common procedure but by considering the following sections of GG paper:

- For Geology (GL) candidates: GA Section + Part A: Common Section + Part B (Section -1): Geology
- For Geophysics (GP) candidates: GA Section + Part A: Common Section + Part B (Section-2): Geophysics

Q46. Will there be a separate rank and score for sectional papers XE, XH and XL?

A46. Yes.

7.4.

7.5. PwD and Dyslexic Candidates

Q47. What are the details of the guidelines that will be followed about PwD candidates writing GATE 2022 examination?

A47. GATE 2022 will follow the guidelines as mentioned in the government regulations. Please refer to PWD_Guidelines: https://gate.iitkgp.ac.in/gate/documents/PWD_Guidelines.pdf

Q48. Will the facility of scribe be given to all PwD candidates?

A48. The facility of scribe is meant for only those PwD candidates who are persons with benchmark disability (i.e. not less than 40% disability) and who have physical limitation to write including that of speed. However, provision of scribe shall be allowed on production of a certificate to the effect that the person concerned has physical limitation to write, as given in APPENDIX-A of this brochure.

In case of person with benchmark disability (i.e. not less than 40% disability) in the category of blindness, locomotor disability (both arms affected-BA) and cerebral palsy, the facility of scribe shall be allowed on advance request only.

In case of person with benchmark disability (i.e. not less than 40% disability) in the category of blindness, locomotor disability (both arms affected-BA) and cerebral palsy, the facility of scribe shall be allowed on advance request only.

(Ref. Para No. IV of OM No. F. No. 34-02/2015-DD-III Dated 29th August, 2018)

Q49. Will there be a “magnified question paper” for visually challenged PwD candidates?

A49. YES. Before beginning of the examination, please contact the GATE Institute Representative through the invigilator in your examination hall and they will do the needful.

Q50. Will the facility of scribe and/or compensatory (extra) time be given to dyslexic candidates?

A50. Yes, dyslexic candidates can avail the services of scribe, provided such candidates submit a proper dyslexic certificate issued by the competent authorities (**Appendix A**). The scribe will be provided by the GATE authorities or candidates may bring their own scribe. The compensatory (extra) time would be applicable to such dyslexic candidates availing the scribe facility.

Q51: Is there a provision of getting compensatory (extra) time for a PwD/dyslexic candidate?

A51. A person with benchmark disability (i.e. not less than 40% disability), who is allowed to avail the facility of scribe (see FAQ 48 above) will automatically get additional one hour compensatory (extra) time for an examination of three hours duration.

PwD/dyslexic candidates, with certain benchmark disabilities (that limits the speed of writing) who do not want to avail the scribe assistance, but at the same time request for compensatory time during the time of application, may be considered for an extra time of one hour **only if fulfilling the criteria of scribe as per the question No.48**.

Q52. Will the facility of own scribe be given to person with benchmark disabilities (that limits the speed of writing)?

A52. Yes, subject to fulfilling criteria of scribe as per PwD FAQ No.2 above, persons with benchmark disability (i.e. not less than 40% disability) will be allowed to opt for their own scribe, provided the qualification of the scribe is one step below the qualification of the candidate taking the examination. The candidate with benchmark disabilities (i.e. not less than 40% disability) opting for their own scribe should submit details of their own scribe as per proforma in Appendix A of the GATE 2022 information brochure. Scribe details must include latest qualification and identity documents. (Ref. Para No. VI of OM No. F. No. 34-02/2015-DD-III Dated 29th August, 2018)

Q53. Can I request for a scribe at the examination centre on the day of examination?

A53. NO. On-the-spot request for scribe at the examination hall will NOT be entertained.

8. Contact Information

GATE 2022 is jointly administered and conducted by the Indian Institute of Science (IISc) Bangalore and seven Indian Institutes of Technology (IITs) at Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras, Roorkee.

Table 8.1 gives the details of each Zonal Office. Each of the institutes administer a zone and caters to a list of examination cities that fall under that zone (Table 4.4). Candidates are assigned a zone at the time of application, based on the first choice of city. Candidates must note this zone number for future references. Any queries regarding the application, examination centre, Admit Card, and result are handled by the respective GATE 2022 zonal institute in consultation with the Organising Institute.

Candidates must first try to read FAQs. If a query is not resolved even after going through FAQs, then they should contact the zonal GATE offices, which will provide quicker and clearer information.

Table 8.1 Contact Details for Zonal GATE Offices

Zone No	Contact Address	Phone Number	E-mail Id
Zone-1	**Chairperson, GATE Indian Institute of Science, Bangalore, Bengaluru 560012**	**080-22932392 080-23601227**	gate@gate.iisc.ac.in
Zone-2	**Organising Chairperson, GATE Indian Institute of Technology Bombay, Powai, Mumbai 400076**	**022-25767068**	gateoffice@iitb.ac.in
Zone-3	**Chairperson, GATE Indian Institute of Technology Delhi, Hauz Khas, New Delhi 110016**	**011-26591749**	gate@admin.iitd.ac.in
Zone-4	**Chairperson, GATE Indian Institute of Technology Guwahati, Guwahati 781039**	**0361-2582751 0361-2582755**	gate@iitg.ac.in
Zone-5	**Chairperson, GATE Indian Institute of Technology Kanpur, Kanpur 208016**	**0512-2597412**	gate@iitk.ac.in
Zone-6	**Chairperson, GATE Indian Institute of Technology Kharagpur, Kharagpur 721302**	**03222-282091 03222-282095**	gateonline@adm.iitkgp.ac.in
Zone-7	**Chairperson, GATE Indian Institute of Technology Madras, Chennai 600036**	**044-22578200**	gate@iitm.ac.in
Zone-8	**Chairperson, GATE Indian Institute of Technology Roorkee, Roorkee 247667**	**01332-284531**	gate@iitr.ac.in

Appendix A

Authorities Empowered to Issue SC / ST Certificates

•District Magistrate / Additional District Magistrate / Collector / Deputy Collector / Deputy Commissioner / Additional Deputy Commissioner /1st Class Stipendiary Magistrate / City Magistrate / Sub-Divisional Magistrate / Taluk Magistrate / Executive Magistrate / Extra Assistant Commissioner.

•Chief Presidency Magistrate/Additional Chief Presidency Magistrate/Presidency Magistrate

•Revenue Officer not below the rank of Tahsildar

•Sub-Divisional Officer of the area where the Candidate and/or her/his family normally resides

•Administrator / Secretary to Administrator / Development Officer (Lakshadweep Islands) Certificate issued by any other official will NOT be accepted.

Person with Disability (PwD) Category

In order to avail application fee concession under the PwD category, the candidates should attach a recently obtained proper PwD certificate, which is required to be submitted to the admitting institution at the time of admission. Benefit would be given to those who have benchmark disability i.e. not less than 40% impairment irrespective of the type of disability. The onus of verifying PwD certificate lies with the admitting institute. The GATE committee is NOT responsible for any incorrect declaration of the PwD status of candidates.

Authorities Empowered to Issue 'Certificate of Dyslexia'

A copy of the certificate of Dyslexic condition should be uploaded at the time of online registration to avail the services of scribe. Such certificate of Dyslexic will be obtained from any Dyslexia Association. Some of them are listed below:

1.. Dyslexia Trust of Kolkata, Divya Jalan, Aruna Bhaskar 3, Dover Park, Kolkata – 700019.

2. Dyslexia Association Of Andhra Pradesh (DAAP), 3-4-494/1,1st Floor, Macherla Gastrology Hospital, Reddy College Road, Barkatpura, Hyderabad, Telangana, 500027.

3.. Madras Dyslexia Association, 94 Park View, 1st Floor, G.N. Chetty Road, T. Nagar, Chennai – 600017.

4.. Maharashtra Dyslexia Association, 003, Amit Park Bldg, L J Road, Deonar, Mumbai 400088.

5. The Dyslexia Association of India, MZ-47, The Center Stage Mall, Plot No 01, Block L, Sector 18, Noida, 201303.

Guidelines for Conducting Exam for PwD

F. No. 34-02/2015-DD-III
Government of India
Ministry of Social Justice & Empowerment
Department of Empowerment of of Persons with Disabilities (Divyangjan)
***

Pt. Deendayal Antyodaya Bhawan,
C.G.O. Complex, New Delhi -110003
Dated: the 29th August, 2018

Office Memorandum

Subject: Guidelines for conducting written examination for Persons with Benchmark Disabilities

The undersigned is directed to say that this Department had issued the guidelines for conducting written examination for persons with disabilities defined in terms of erstwhile Persons with Disabilities (Equal Opportunities, Protection for Rights and Full Participation) Act, 1995 vide OM No. 16-110/2003-DD.III dated 26/02/2013. The Department had constituted a Committee under the Chairmanship of Secretary, DEPwD in March, 2015 to review the said guidelines based on the issues raised by Union Public Service Commission and others. Meanwhile the Central Government enacted the Rights of Persons with Disabilities Act, 2016 (RPwD Act, 2016) which came into force from 19.04.2017. The Act provides for reservation in Government jobs for persons with benchmark disabilities as defined under section 2 (r) of the said Act.

Based on the findings of the Committee, the Central Government hereby lays down the revised guidelines for conducting written examination for persons with benchmark disabilities in supersession of the earlier guidelines issued vide OM No. 16-110/2003-DD.III dated 26/02/2013 as under:

I. These guidelines may be called as "Guidelines for conducting written examination for persons with benchmark disabilities 2018".

II. There should be a uniform and comprehensive policy across the country for persons with benchmark disabilities for written examination taking into account improvement in technology and new avenues opened to the persons with benchmark disabilities providing a level playing field. Policy should also have flexibility to accommodate the specific needs on case-to-case basis.

III. There is no need for fixing separate criteria for regular and competitive examinations.

IV. The facility of Scribe/Reader/Lab Assistant should be allowed to any person with benchmark disability as defined under section 2(r) of the RPwD Act, 2016 and has limitation in writing including that of speed if so desired by him/her.

In case of persons with benchmark disabilities in the category of blindness, locomotor disability (both arm affected-BA) and cerebral palsy, the facility of scribe/reader/lab assistant shall be given, if so desired by the person.

In case of other category of persons with benchmark disabilities, the provision of scribe/reader/lab assistant can be allowed on production of a certificate to the effect that the person concerned has physical limitation to write, and scribe is essential to write examination on his behalf, from the Chief Medical Officer/Civil Surgeon/ Medical Superintendent of a Government health care institution as per proforma at **APPENDIX-I**.

V. The candidate should have the discretion of opting for his own scribe/reader/lab assistant or request the Examination Body for the same. The examining body may also identify the scribe/ reader/lab assistant to make panels at the District/Division/ State level as per the requirements of the examination. In such instances the candidates should be allowed to meet the scribe **two days** before the examination so that the candidates get a chance to check and verify whether the scribe is suitable or not.

VI. In case the examining body provides the scribe/reader/lab assistant, it shall be ensured that qualification of the scribe should not be more than the minimum qualification criteria of the examination. However, the qualification of the scribe/reader should always be matriculate or above.

In case the candidate is allowed to bring his own scribe, the qualification of the scribe should be one step below the qualification of the candidate taking examination. The persons with benchmark disabilities opting for own scribe/reader should submit details of the own scribe as per proforma at **APPENDIX-II**

VII. There should also be flexibility in accommodating any change in scribe/reader/lab assistant in case of emergency. The candidates should also be allowed to take more than one scribe/reader for writing different papers especially for languages. However, there can be only one scribe per subject.

VIII. Persons with benchmark disabilities should be given, as far as possible, the option of choosing the mode for taking the examinations i.e. in Braille or in the computer or in large print or even by recording the answers as the examining bodies

can easily make use of technology to convert question paper in large prints, e-text, or Braille and can also convert Braille text in English or regional languages.

IX. In case, the persons with benchmark disabilities are allowed to take examination on computer system, they should be allowed to check the computer system one day in advance so that the problems, if any in the software/system could be rectified. Use of own computer/laptop should not be allowed for taking examination. However, enabling accessories for the computer based examinations such as keyboard, customized mouse etc should be allowed.

X. The procedure of availing the facility of scribe should be simplified and the necessary details should be recorded at the time of filling up of the forms. Thereafter, the examining body should ensure availability of question papers in the format opted by the candidate as well as suitable seating arrangement for giving examination.

XI. The disability certificate issued by the competent medical authority at any place should be accepted across the country.

XII. The word "extra time or additional time" that is being currently used should be changed to "compensatory time" and the same should not be less than 20 minutes per hour of examination for persons who are allowed use of scribe/reader/lab assistant. All the candidates with benchmark disability not availing the facility of scribe may be allowed additional time of minimum of one hour for examination of 3 hours duration. In case the duration of the examination is less than an hour, then the duration of additional time should be allowed on pro-rata basis. Additional time should not be less than 5 minutes and should be in the multiple of 5.

XIII. The candidates should be allowed to use assistive devices like talking calculator (in cases where calculators are allowed for giving exams), tailor frame, Braille slate, abacus, geometry kit, Braille measuring tape and augmentative communication devices like communication chart and electronic devices.

XIV. Proper seating arrangement (preferably on the ground floor) should be made prior to the commencement of examination to avoid confusion or distraction during the day of the exam. The time of giving the question papers should be marked accurately and timely supply of supplementary papers should be ensured.

XV. As far as possible, the examining body should also provide reading material in Braille or E-Text or on computers having suitable screen reading software for open book examination. Similarly online examination should be in accessible format i.e. websites, question papers and all other study material should be accessible as per the international standards laid down in this regard.

XVI. Alternative objective questions in lieu of descriptive questions should be provided for Hearing-Impaired persons, in addition to the existing policy of giving alternative questions in lieu of questions requiring visual inputs, for persons with Visual Impairment.

XVII. As far as possible the examination for persons with disabilities should be held at the ground floor. The examination centres should be accessible for persons with disabilities.

2. It is requested to ensure that the above guidelines are scrupulously followed while conducting examination for persons with benchmark disabilities. All the recruitment agencies, Academics/Examination Bodies etc. under the administrative control of each Ministry/Deapartment may be advised appropriately to ensure compliance of implementing these guidelines. Action taken in this regard may be intimated to this office.

3. The above guidelines are issued with the approval of Hon'ble Minister (Social Justice & Empowerment).

Yours faithfully,

(D.K. Panda)
Under Secretary to the Government of India
Tele. No. 24369059

To

1. Secretary of all Ministries/Department.

2. Secretary, UPSC, Shahjahan Road, New Delhi.

3. Chairman, SSC, Block No.12, CGO Complex, Lodhi Road, New Delhi-110003.

4. Chairman, University Grants Commission with a request to issue necessary instructions to all universities including Deemed Universities for compliance.

5. Chairman, Railway Board

6. All National Institutes and RCI under administrative control of Department of Empowerment of Persons with Disabilities (Divyangjan), Ministry of SJ&E, New Delhi

Copy for information to: CCPD, Sarojini Bhawan, Bhagwan Dass Road, New Delhi

APPENDIX- I

Certificate regarding physical limitation in an examinee to write

This is to certify that, I have examined Mr/Ms/Mrs _____ (name of the candidate with disability), a person with _____ (nature and percentage of disability as mentioned in the certificate of disability), S/o/D/o _____, a resident of _____ (Village/District/State) and to state that he/she has physical limitation which hampers his/her writing capabilities owing to his/her disability.

Signature

Chief Medical Officer/Civil Surgeon/ Medical Superintendent of a Government health care institution

Name & Designation.

Name of Government Hospital/Health Care Centre with Seal

Place:

Date:

Note:

Certificate should be given by a specialist of the relevant stream/disability (eg. Visual impairment – Ophthalmologist, Locomotor disability – Prthopaedic specialist/PMR).

APPENDIX- II

Letter of Undertaking for Using Own Scribe

I _____, a candidate with _____ (name of the disability) appearing for the _____ (name of the examination) bearing Roll No. _____ at _____ (name of the centre) in the District _____, _____ (name of the State). My qualification is _____.

I do hereby state that _____ (name of the scribe) will provide the service of scribe/reader/lab assistant for the undersigned for taking the aforesaid examination.

I do hereby undertake that his qualification is _____. In case, subsequently it is found that his qualification is not as declared by the undersigned and is beyond my qualification, I shall forfeit my right to the post and claims relating thereto.

(Signature of the candidate with Disability)

Place:

Date:

F. No. 34-02/2015-DD-III (pt)
Government of India
Ministry of Social Justice & Empowerment
Department of Empowerment of of Persons with Disabilities (Divyangjan)

***

Pt. Deendayal Antyodaya Bhawan,
C.G.O. Complex, New Delhi -110003
Dated the 8th February, 2019

Corrigendum

Sub:- Guidelines for conducting written examination for Persons with Benchmark Disabilities

This Department's O.M. No.34-02/2015-DD.III dated 29/08/2018 prescribing the guidelines for conducting written examination for persons with disabilities is amended as under:

Para XII on page 3 of the above guidelines may be substituted with the following-

"The word "extra time or additional time" that is being currently used should be changed to "compensatory time" and the same should not be less than 20 minutes per hour of examination for persons who are allowed use of scribe/reader/lab assistant. All the candidates with benchmark disabilities who are eligible for availing the facility of scribe in terms of guidelines IV may be allowed additional time of minimum of one hour for examination of 3 hours duration whether they use the facility of scribe or not. In case the duration of the examination is less than an hour, then the duration of additional time should be allowed on pro-rata basis. Additional time should not be less than 5 minutes and should be in the multiple of 5"

(K.V.S. Rao)
Director
Tele. No. 24369054

To

1. Secretary of all Ministries/Department.

2. Secretary, UPSC, Shahjahan Road, New Delhi.

3. Chairman, SSC, Block No.12, CGO Complex, Lodhi Road, New Delhi-110003.

4. Chairman, University Grants Commission with a request to issue necessary instructions to all universities including Deemed Universities for compliance.

5. Chairman, Railway Board

6. All National Institutes and RCI under administrative control of Department of Empowerment of Persons with Disabilities (Divyangjan), Ministry of SJ&E, New Delhi

Copy for information to: CCPD, Sarojini Bhawan, Bhagwan Dass Road, New Delhi

Appendix B: Code of Conduct for GATE 2022 Examination

CODE OF CONDUCT

All the candidates appearing for GATE 2022 Examination MUST comply strictly with the following Rules and Regulations:

•Candidates appearing for GATE 2022 examination MUST carry Admit Card and ORIGINAL valid photo-identity proof (which was used at the time of registration) inside the examination hall.

•Scribble pad will be provided to the candidate in the examination hall by the invigilator. The same should be used for all rough work. Candidates MUST write their name and registration number on the scribble pad before they start using it. The candidate can possess ONLY one scribble pad at any point of time. Before taking the second scribble pad, if required, the first scribble pad MUST be returned to the invigilator. Any scribble pad in the possession of the candidate MUST be returned to the invigilators after the end of the examination.

•Carrying mobile phones (even in the switched-off mode), watches of any form and calculators inside the examination hall is strictly PROHIBITED.

•Carrying of any electronic / communication devices, wallets, papers, loose sheets, pen/pencil box/pouch, and printed or hand-written textual materials, inside the examination hall is strictly PROHIBITED.

•All means of communication (verbal or otherwise) among the candidates inside the examination hall are strictly PROHIBITED.

•If any of the PROHIBITED acts or items listed above are detected during the examination, it will automatically lead to CANCELLATION of candidature. Results will NOT be declared for such candidates.

•The Organising Institute / concerned Examination Centre will not take any kind of responsibility regarding safety and security of Mobile Phones / Electronic Devices / any kind of Valuables belonging to candidates.

•Candidates MUST not tamper with the computer and the related hardware provided in the examination hall. Candidates found to have tampered with these wilfully, will have their candidature cancelled summarily. In addition, appropriate legal action will be initiated against such candidates.

•If COVID-19 pandemic situation continues, the candidate MUST follow all the safety regulations at the examination premises as instructed by GATE committee in line with the Government guidelines. Failure to fulfil any of the specified norms will lead to the cancellation of candidature at any point of time.

The candidature of candidates found using unfair means and not in line with the code and ethics of the GATE 2022 examination will be CANCELLED. Their examination will not be evaluated, even if they may have been allowed to complete their examination. In addition, appropriate legal action may be initiated against all such candidates.

Appendix C: Syllabus Content

GA	General Aptitude

Verbal Aptitude

Basic English grammar: tenses, articles, adjectives, prepositions, conjunctions, verb-noun agreement, and other parts of speech Basic vocabulary: words, idioms, and phrases in context Reading and comprehension Narrative sequencing

Quantitative Aptitude

Data interpretation: data graphs (bar graphs, pie charts, and other graphs representing data), 2- and 3-dimensional plots, maps, and tables Numerical computation and estimation: ratios, percentages, powers, exponents and logarithms, permutations and combinations, and series
Mensuration and geometry Elementary statistics and probability

Analytical Aptitude

Logic: deduction and induction, Analogy, Numerical relations and reasoning

Spatial Aptitude

Transformation of shapes: translation, rotation, scaling, mirroring, assembling, and grouping
Paper folding, cutting, and patterns in 2 and 3 dimensions

Sample questions

Verbal Aptitude

Q.1 Out of the following four sentences, select the most suitable sentence with respect to grammar and usage.

(A) I will not leave the place until the minister does not meet me.

(B) I will not leave the place until the minister doesn't meet me.

(C) I will not leave the place until the minister meet me.

(D) I will not leave the place until the minister meets me.

ANSWER: D

Q.2 Indian currency notes show the denomination indicated in at least seventeen languages. If this is not an indication of the nation's diversity, nothing else is.

Which of the following can be logically inferred from the above sentences?

(A) India is a country of exactly seventeen languages.

(B) Linguistic pluralism is the only indicator of a nation's diversity.

(C) Indian currency notes have sufficient space for all the Indian languages.

(D) Linguistic pluralism is strong evidence of India's diversity.

ANSWER: D

Q.3 The unruly crowd demanded that the accused be _____ without trial.

(A) hanged (B) hanging (C) hankering (D) hung

ANSWER: A

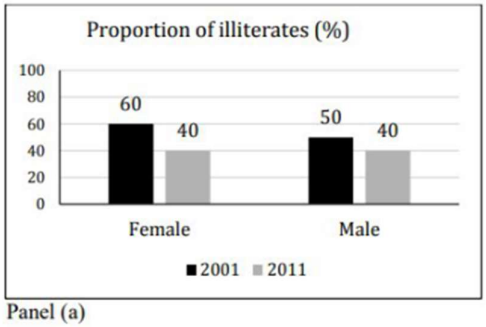
Q.4 Archimedes said, “Give me a lever long enough and a fulcrum on which to place it, and I will move the world.”
The sentence above is an example of a _____ statement.

(A) figurative (B) collateral (C) literal (D) figurine

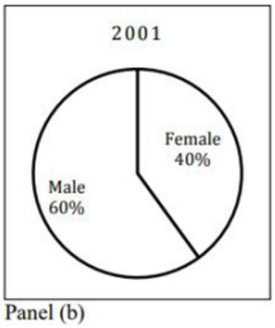
ANSWER: A
Quantitative Aptitude

ANSWER: A

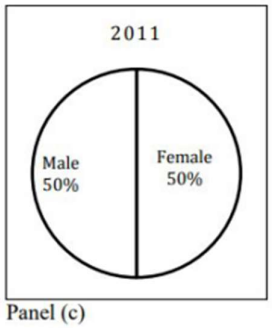
Q.5 The bar graph in Panel (a) shows the proportion of male and female illiterates in 2001 and 2011. The proportions of males and females in 2001 and 2011 are given in panel (b) and (c) respectively. The total population did not change during this period. The percentage increase in the total number of literates from 2001 to 2011 is --------



Panel (a)



Panel (b)



Panel (c)

(A) 30.43 (B) 33.43 (C) 34.43 (D) 35.43

Q.6 If pqr ≠ 0 and $p^{-x} = \frac{1}{q}$, $q^{-y} = \frac{1}{r}$, $r^{-z} = \frac{1}{p}$, what is the value of the product xyz?

(A) -1 (B) $\frac{1}{pqr}$ (C) 1 (D) pqr

ANSWER: C

Q.7 An e-mail password must contain three characters. The password has to contain one numeral from 0 to 9, one upper case and one lower case character from the English Alphabet. How many distinct passwords are possible?

(A) 6,760 (B) 13,520 (C) 40,560 (D) 1,05,456

ANSWER: C

Q.8 The area of a square is d. What is the area of the circle which has the diagonal of the square as its diameter?

(A) πd (B) πd^2 (C) $\frac{\pi d^2}{4}$ (D) $\frac{1}{2}\pi d$

ANSWER: D

Analytical Aptitude

Q.9 Computers were invented for performing only high-end useful computations. However, it is no understatement that they have taken over our world today. The internet, for example, is ubiquitous. Many believe that the internet itself is an unintended consequence of the original invention. With the advent of mobile computing on our phones, a whole new dimension is now enabled. One is left wondering if all these developments are good or, more importantly, required. Which of the statement(s) below is/are logically valid and can be inferred from the above paragraph?

(i) The author believes that computers are not good for us.
(ii) Mobile computers and the internet are both intended inventions.

(A) (i) only

(B) (ii) only

(C) both (i) and (ii)

(D) neither (i) nor (ii)

Answer D

Q.10 Some students were not involved in the strike

If the above statement is true, which of the following conclusions is/are logically necessary?

(i). Some who were involved in the strike were students.
(ii). No student was involved in the strike
(iii). At least one student was involved in the strike
(iv). Some who were not involved in the strike were students.

(A) (i) and (ii)
(B) (iii)
(C) (iv)
(D) (ii) and (iii)

Answer C.

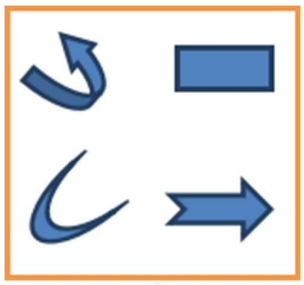
Spatial Aptitude

Q.11 A rectangular sheet of length 6cm and breadth 4cm is coiled to form an open cylinder (say, P) such that the breadth sides meet. The same sheet can also be coiled to form a cylinder (say, Q) such that the length sides meet. Which one of the following statements is **FALSE**?

Surface area of the open cylinders P and Q are equal.
Volume of P and Volume of Q are equal.
Volume of P is greater than that of Q.
The height of cylinder Q is greater than that of P.

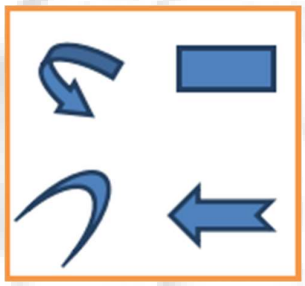
Answer: B

Q12

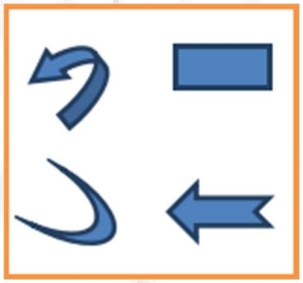


Which one of the following closely resembles the mirror image of the above figure?

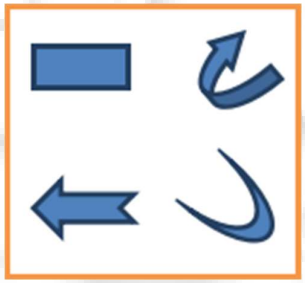
A.



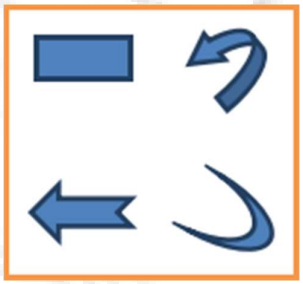
B.



C.



D.



Answer: C

AE	Aerospace Engineering

Important Note for Candidates: In each of the following subjects the topics have been divided into two categories – Core Topics and Special Topics. The corresponding sections of the question paper will contain 90% of their questions on Core Topics and the remaining 10% on Special Topics.

Section1: Engineering Mathematics

Core Topics:

Linear Algebra: Vector algebra, Matrix algebra, systems of linear equations, rank of a matrix, eigenvalues and eigenvectors.

Calculus: Functions of single variable, limits, continuity and differentiability, mean value theorem, chain rule, partial derivatives, maxima and minima, gradient, divergence and curl, directional derivatives. Integration, Line, surface and volume integrals. Theorems of Stokes, Gauss and Green.

Differential Equations: First order linear and nonlinear differential equations, higher order linear ODEs with constant coefficients. Partial differential equations and separation of variables methods.

Special Topics: Fourier Series, Laplace Transforms, Numerical methods for linear and nonlinear algebraic equations, Numerical integration and differentiation. Complex analysis. Probability and statistics.

Section 2: Flight Mechanics

Core Topics:

Basics

Atmosphere: Properties, standard atmosphere. Classification of aircraft. Airplane (fixed wing aircraft) configuration and various parts. Pressure altitude; equivalent, calibrated, indicated air speeds; Primary flight instruments: Altimeter, ASI, VSI, Turn-bank indicator. Angle of attack, sideslip; Roll, pitch & yaw controls. Aerodynamic forces and moments.

Airplane performance: Drag polar; takeoff and landing; steady climb & descent; absolute and service ceiling; range and endurance, load factor, turning flight, V-n diagram. Winds: head, tail & cross winds.

Static stability: Stability & control derivatives; longitudinal stick fixed & free stability; horizontal tail position and size; directional stability, vertical tail position and size; lateral stability. Wing dihedral, sweep & position; hinge moments, stick forces.

Special Topics: Dynamic stability: Euler angles; Equations of motion; Decoupling of longitudinal and lateral-directional dynamics; longitudinal modes; lateral-directional modes.

Section 3: Space Dynamics

Core Topics:
Central force motion, determination of trajectory and orbital period in simple cases. Kepler's laws; escape velocity.

No Special Topics:

Section 4: Aerodynamics

Core Topics:

Basic Fluid Mechanics: Conservation laws: Mass, momentum and energy (Integral and differential form); Dimensional analysis and dynamic similarity;

Potential flow theory: sources, sinks, doublets, line vortex and their superposition. Elementary ideas of viscous flows including boundary layers.

Airfoils and wings: Airfoil nomenclature; Aerodynamic coefficients: lift, drag and moment; Kutta-Joukoswki theorem; Thin airfoil theory, Kutta condition, starting vortex; Finite wing theory: Induced drag, Prandtl lifting line theory; Critical and drag divergence Mach number.

Compressible Flows: Basic concepts of compressibility, One-dimensional compressible flows, Isentropic flows, Fanno flow, Rayleigh flow; Normal and oblique shocks, Prandtl-Meyer flow; Flow through nozzles and diffusers.

Special Topics: Wind Tunnel Testing: Measurement and visualization techniques. Shock - boundary layer interaction.

Section 5: Structures

Core Topics:

Strength of Materials: Stress and strain: Three-dimensional transformations, Mohr's circle, principal stresses, Three-dimensional Hooke's law, Plane stress and strain. Failure theories: Maximum stress, Tresca von Mises. Strain energy. Castigliano's principles. Statically determinate and indeterminate trusses and beams. Elastic flexural buckling of columns.

Flight vehicle structures: Characteristics of aircraft structures and materials. Torsion, bending and shear of thin-walled sections. Loads on aircraft.

Structural Dynamics: Free and forced vibrations of undamped and damped SDOF systems. Free vibrations of undamped 2-DOF systems.

Special Topics: Vibration of beams. Theory of elasticity: Equilibrium and compatibility equations, Airy's stress function.

Section 6: Propulsion

Core Topics:

Basics:Thermodynamics, boundary layers, heat transfer, combustion and thermochemistry.

Aerothermodynamics of aircraft engines: Thrust, efficiency, range. Brayton cycle.

Engine performance: ramjet, turbojet, turbofan, turboprop and turboshaft engines. Afterburners.

Turbomachinery: Axial compressors: Angular momentum, work and compression, characteristic performance of a single axial compressor stage, efficiency of the compressor and degree of reaction, multi-staging.

Centrifugal compressor: Stage dynamics, inducer, impeller and diffuser.

Axial turbines: Stage performance.

Rockets: Thrust equation and specific impulse, rocket performance. Multi-staging. Chemical rockets. Performance of solid and liquid propellant rockets.

Special Topics: Aerothermodynamics of non-rotating propulsion components such as intakes, combustor and nozzle. Turbine blade cooling. Compressor-turbine matching, Surge and stall.

AG Agricultural Engineering

Section 1: Engineering Mathematics

Linear Algebra: Matrices and determinants, linear and orthogonal transformations, Caley Hamilton theorem; Eigenvalues and Eigenvectors, solutions of linear equations.

Calculus: Limit, continuity and differentiability; partial derivatives; homogeneous function – Euler's theorem on homogeneous functions, total differentiation; maxima and minima of function with several independent variables; sequences and series – infinite series, tests for convergence; Fourier, Taylor and MacLaurin series.

Vector Calculus: Vector differentiation, scalar and vector point functions, vector differential operators – del, gradient; divergence and curl; physical interpretations-line, surface and volume integrals;Stokes, Gauss and Green's theorems.

Differential Equations: Linear and non-linear first order Ordinary Differential Equations (ODE); homogeneous differential equations, higher order linear ODEs with constant coefficients; Laplace transforms and their inverse; Partial Differential Equations - Laplace, heat and wave equations.

Probability and Statistics: Mean, median, mode and standard deviation; random variables; Poisson, normal and binomial distributions; correlation and regression analysis.

Numerical Methods: Solutions of linear and non-linear algebraic equations; numerical integration - trapezoidal and Simpson's rule; numerical solutions of ODEs.

Section 2: Farm Machinery

Machine Design: Design and selection of machine elements – gears, pulleys, chains and sprockets and belts; overload safety devices used in farm machinery; measurement of force, stress, torque, speed, displacement and acceleration on machine elements - shafts, couplings, keys, bearings and knuckle joints.

Farm Machinery: Soil tillage; forces acting on a tillage tool; hitch systems and hitching of tillage implements; functional requirements, principles of working, construction and operation of manual, animal and power operated equipment for tillage, sowing, planting, fertilizer application, inter-cultivation, spraying, mowing, chaff cutting, harvesting and threshing calculation of performance

parameters - field capacity, efficiency, application rate and losses; cost analysis of implements and tractors.

Section 3: Farm Power

Sources of Power: Sources of power on the farm - human, animal, mechanical, electrical, wind, solar and biomass; bio-fuels.

Farm Power: Thermodynamic principles of I.C. engines; I.C. engine cycles; engine components; fuels and combustion; lubricants and their properties; I.C. engine systems – fuel, cooling, lubrication, ignition, electrical, intake and exhaust; selection, operation, maintenance and repair of I.C. engines; power efficiencies and measurement; calculation of power, torque, fuel consumption, heat load and power losses; performance index, cost analysis of implements and tractors.

Tractors and Power tillers: Type, selection, maintenance and repair of tractors and power tillers; tractor clutches and brakes; power transmission systems – gear trains, differential, final drives and power take-off; mechanics of tractor chassis; traction theory; three point hitches - free link and restrained link operations; steering and hydraulic control systems used in tractors; tractor tests and performance; human engineering and safety considerations in design of tractor and agricultural implements.

Section 4: Soil and Water Conservation Engineering

Fluid Mechanics: Ideal and real fluids, properties of fluids; hydrostatic pressure and its measurement; continuity equation, kinematics and dynamics of flow; Bernoulli's theorem; laminar and turbulent flow in pipes, Darcy- Weisbach and Hazen-Williams equations, Moody's diagram; flow through orifices, weirs and notches; flow in open channels, dimensional analysis – concepts of geometric dimensionless numbers.

Soil Mechanics: Engineering properties of soils; fundamental definitions and relationships; index properties of soils; permeability and seepage analysis; shear strength, Mohr's circle of stress, active and passive earth pressures; stability of slopes, Terzaghi's one dimensional soil consolidation theory.

Hydrology: Hydrological cycle and measurement of its components; meteorological parameters and their measurement; analysis of precipitation data; runoff estimation; hydrograph analysis, unit hydrograph theory and application; streamflow measurement; flood routing, hydrological reservoir and channel routing, Infiltration – indices and equations, drought and its classification.

Surveying and Leveling: Measurement of distance and area; instruments for surveying and leveling; chain surveying, methods of traversing; measurement of angles and bearings, plane table surveying; types of leveling; theodolite traversing; contouring; total station, introduction to GPS survey, computation of areas and volume.

Soil and Water Erosion: Mechanics of soil erosion - wind and water erosion: soil erosion types, factors affecting erosion; soil loss estimation; biological and engineering measures to control erosion; terraces and bunds; vegetative waterways; gully control structures, drop, drop inletand chute spillways; earthen dams.

Watershed Management: Watershed characterization and land use capability classification; water budgeting in watershed, rainwater harvesting, check dams and farm ponds.

Section 5: Irrigation and Drainage Engineering

Soil-Water-Plant Relationship: Water requirement of crops; consumptive use and evapotranspiration; measurement of infiltration, soil moisture and irrigation water infiltration.

Irrigation Water Conveyance and Application Methods: Design of irrigation channels and underground pipelines; irrigation scheduling; surface, sprinkler and micro irrigation methods, design and evaluation of irrigation methods; irrigation efficiencies.

Agricultural Drainage: Drainage coefficient; planning, design and layout of surface and sub-surface drainage systems; leaching requirement and salinity control; irrigation and drainage water quality and reuse; non-conventional drainage system.

Groundwater Hydrology: Groundwater occurrence; Darcy's Law, steady and unsteady flow in confined and unconfined aquifers, groundwater exploration techniques; overview of groundwater recharge estimation and artificial recharge techniques.

Wells and Pumps: Types of wells, steady flow through wells; design and construction of water wells; classification of pumps; pump characteristics; pump selection and installation.

Section 6: Agricultural Process Engineering

Engineering properties of agriculture produce: Physical, thermal, frictional, rheological and electrical properties.

Evaporation and Drying: Concentration and drying of liquid foods – evaporators, tray, drum and spray dryers; hydrothermal treatments; drying and milling of cereals, pulses and oilseeds; drying kinetics; psychrometry – properties of air-water vapor mixture.

Size Reduction and Material Handling: Mechanics and energy requirement in size reduction of agriculture produce; particle size analysis for comminuted solids; size separation by screening; fluidization of granular solids-pneumatic, bucket, screw and belt conveying; cleaning and grading; effectiveness of separation; centrifugal separation of solids, liquids and gases; homogenization; filtration and membrane separation.

Processing of Agriculture Produce: Processing of seeds, spices, fruits and vegetables; value addition of agriculture produce.

Storage Systems: Controlled and modified atmosphere storage; perishable food storage, godowns, bins and grain silos, packaging material and machines.

Section 7: Dairy and Food Engineering

Heat and Mass Transfer: Steady state heat transfer in conduction, convection and radiation; transient heat transfer in simple geometry; working principles of heat exchangers; diffusive and convective mass transfer; simultaneous heat and mass transfer in agricultural processing operations; material and energy balances in food processing systems; water activity, sorption and desorption isotherms.

Preservation of Food: Kinetics of microbial death – pasteurization and sterilization of milk and other liquid foods; preservation of food by cooling and freezing; refrigeration and cold storage basics and applications.

AR	Architecture and Planning

Part A: Common

Section 1: Architecture, Planning and Design

Architectural Graphics; Visual composition in 2D and 3D; Computer application in Architectureand Planning; Anthropometrics; Organization of space; Circulation- horizontal and vertical; Space Standards; Universal design; Building byelaws; Codes and standards;

Section 2: Construction and Management

Project management techniques e.g. PERT, CPM etc. ; Estimation and Specification; Professional practice and ethics; Form and Structure; Principles and design of disaster resistant structures; Temporary structures for rehabilitation;

Section 3: Environmental Planning and Design

Natural and man-made ecosystem; Ecological principles; Environmental considerations in Planning and design; Environmental pollution- types, causes, controls and abatement strategies; Sustainable development, goals and strategies; Climate change and built environment; Climate responsive design;

Section 4: Urban Design, landscape and Conservation

Historical and modern examples of urban design; Elements of urban built environment – urban form, spaces, structure, pattern, fabric, texture, grain etc.; Concepts and theories of urban design; Principles, tools and techniques of urban design; Public spaces, character, spatial qualities and Sense of Place; Urban design interventions for sustainable development and transportation; Development controls – FAR, densities and building byelaws.; Urban renewal and conservation; heritage conservation; historical public spaces and gardens; Landscape design; Site planning;

Section 5: Planning process

Salient concepts, theories and principles of urban planning; concepts of cities - Eco-City, Smart City; Concepts and theories by trendsetting planners and designers; Ekistics; Urban sociology; Social, Economic and environmental cost benefit analysis; Methods of non-spatial and spatial data analysis; Development guidelines such as URDPFI;

Section 6: Housing

Housing typologies; Concepts, principles and examples of neighbourhood; Residential densities; Affordable Housing; Real estate valuation;

Section 7: Services and Infrastructure

Firefighting Systems; Building Safety and Security systems; Building Management Systems; Water treatment; Water supply and distribution system; Water harvesting systems; Principles, Planning and Design of storm water drainage system; Sewage disposal methods; Methods of solid waste management - collection, transportation and disposal; Recycling and Reuse of solid waste; Land-use – transportation - urban form inter-relationships; Design of roads, intersections, grade separators and parking areas; Hierarchy of roads and level of service; Para-transits and other modes of transportation, Pedestrian and slow moving traffic planning;

Part B1: Architecture

Section B1.1: History and Contemporary Architecture

Principles of Art and Architecture; World History of Architecture: Egyptian, Greco-Roman classical period, Byzantine, Gothic, Renaissance, Baroque-Rococo, etc.; Recent trends in Contemporary Architecture: Art nouveau, Art Deco, Eclecticism, International styles, Post Modernism, Deconstruction in architecture, etc.; Influence of Modern art and Design in Architecture; Indian vernacular and traditional Architecture, Oriental Architecture; Works of renowned national and international architects;

Section B1.2: Building Construction and Structural systems

Building construction techniques, methods and details; Building systems and prefabrication of building elements; Principles of Modular Coordination; Construction planning and equipment; Building material characteristics and applications; Principles of strength of materials; Alternative building materials; Foundations; Design of structural elements with different materials; Elastic and Limit State design; Structural systems; Principles of Pre-stressing; High Rise and Long Span structures, gravity and lateral load resisting systems;

Section B1.3: Building Services and Sustainability

Solar architecture; Thermal, visual and acoustic comfort in built environments; Natural and Mechanical ventilation in buildings; Air-Conditioning systems; Sustainable building strategies; Building Performance Simulation and Evaluation; Intelligent Buildings; Water supply; Sewerage and drainage systems; Sanitary fittings and fixtures; Plumbing systems; Principles of internal and external drainage system; Principles of electrification of buildings; Elevators and Escalators - standards and uses;

Part B2: Planning

Section B2.1: Regional and Settlement Planning

Regional delineation; settlement hierarchy; Types and hierarchy of plans; Various schemes and programs of central government; Transit Oriented Development (TOD), SEZ, SRZ etc.; Public Perception and user behaviour; National Housing Policies, Programs and Schemes.; Slums, Squatters and informal housing; Standards for housing and community facilities; Housing for special areas and needs;

Section B2.2: Planning Techniques and Management

Application of G.I.S and Remote Sensing techniques in urban and regional planning; Tools and techniques of Surveys – Physical, Topographical, Land use and Socio-economic Surveys; Urban Economics, Law of demand and supply of land and its use in planning; Graphic presentation of spatial data; Local self-governance, Panchayatiraj institutions; Planning Legislation and implementation – Land Acquisition Act, PPP etc.; Decision support system and Land Information System; Urban geography and econometrics; Management of Infrastructure Projects; Demography and equity in planning;

Section B2.3: Infrastructure Planning

Process and Principles of Transportation Planning and Traffic Engineering; Road capacity and Travel demand forecasting; Traffic survey methods, Traffic flow Analysis; Traffic analyses and design considerations; Traffic and transport management and control in urban areas; Mass transportation planning; Intelligent Transportation Systems; Urban and Rural Infrastructure System Network.

BM	Biomedical Engineering

Engineering Mathematics:

Linear Algebra: Matrix algebra, systems of linear equations, Eigenvalues and Eigenvectors.

Calculus: Mean value theorems, theorems of integral calculus, partial derivatives, maxima and minima, multiple integrals, Fourier series, vector identities, line, surface and volume integrals, Stokes, Gauss and Green's theorems.

Differential equations: First order linear and nonlinear differential equations, higher order linear differential equations with constant coefficients, method of separation of variables, Cauchy's and Euler's equations, initial and boundary value problems, solution of partial differential equations.

Analysis of complex variables: Analytic functions, Cauchy's integral theorem and integral formula, Taylor's and Laurent's series, residue theorem.

Probability and Statistics: Sampling theorems, conditional probability, mean, median, mode and standard deviation, random variables, discrete and continuous distributions: normal, Poisson and binomial distributions. Tests of Significance, statistical power analysis, and sample size estimation. Linear Regression and correlation analysis;

Numerical Methods: Matrix inversion, numerical solutions of nonlinear algebraic equations, iterative methods for solving differential equations, numerical integration.

Electrical Circuits:

Voltage and current sources - independent, dependent, ideal and practical; v-i relationships of resistor, inductor and capacitor; transient analysis of RLC circuits with dc excitation; Kirchoff's laws, superposition, Thevenin, Norton, maximum power transfer and reciprocity theorems; Peak, average and rms values of ac quantities; apparent, active and reactive powers; phasor analysis, impedance and admittance; series and parallel resonance, realization of basic filters with R, L and C elements, Bode plot.

Signals and Systems:

Continuous and Discrete Signal and Systems - Periodic, aperiodic and impulse signals; Sampling theorem; Laplace and Fourier transforms; impulse response of systems; transfer function, frequency response of first and second order linear time invariant systems, convolution, correlation. Discrete time systems - impulse response, frequency response, DFT, Z - transform; basics of IIR and FIR filters.

Analog and Digital Electronics:

Basic characteristics and applications of diode, BJT and MOSFET; Characteristics and applications of operational amplifiers - difference amplifier, adder, subtractor, integrator, differentiator, instrumentation amplifier, buffer, filters and waveform generators. Number systems, Boolean algebra; combinational logic circuits - arithmetic circuits, comparators, Schmitt trigger, encoder/decoder, MUX/DEMUX, multi-vibrators; Sequential circuits - latches and flip flops, state diagrams, shift registers and counters; Principles of ADC and DAC; Microprocessor- architecture, interfacing memory and input- output devices.

Measurements and Control Systems:

SI units, systematic and random errors in measurement, expression of uncertainty -accuracy and precision index, propagation of errors; PMMC, MI and dynamometer type instruments; dc potentiometer; bridges for measurement of R, L and C, Q-meter. Basics of control system - transfer function.

Sensors and Bioinstrumentation:

Sensors - resistive, capacitive, inductive, piezoelectric, Hall effect, electro chemical, optical; Sensor signal conditioning circuits; application of LASER in sensing and therapy. Origin of biopotentials and their measurement techniques - ECG, EEG, EMG, ERG, EOG, GSR, PCG, Principles of measuring blood pressure, body temperature, volume and flow in arteries, veins and tissues, respiratory measurements and cardiac output measurement. Operating principle of medical equipment - sphygmomanometer, ventilator, cardiac pacemaker, defibrillator, pulse oximeter, hemodialyzer Electrical Isolation (optical and electrical) and Safety of Biomedical Instruments.

Human Anatomy and Physiology:

Basics of cell, types of tissues and organ systems; Homeostasis; Basics of organ systems - musculoskeletal, respiratory, circulatory, excretory, endocrine, nervous, gastro-intestinal and reproductive.

Medical Imaging Systems:

Basic physics, Instrumentation and image formation techniques in medical imaging modalities such as X-Ray, Computed Tomography, Single Photon Emission Computed Tomography, Positron Emission Tomography, Magnetic Resonance Imaging, Ultrasound.

Biomechanics:

Kinematics of muscles and joints - free-body diagrams and equilibrium, forces and stresses in joints, biomechanical analysis of joints, Gait analysis; Hard Tissues - Definition of Stress and Strain, Deformation Mechanics, structure and mechanical properties of bone - cortical and cancellous bones; Soft Tissues - Structure, functions, material properties, viscoelastic properties, Maxwell & Voight models; Biofluid mechanics - Flow properties of blood in the intact human cardiovascular system.

Biomaterials:

Basic properties of biomaterials - Metallic, Ceramic, Polymeric and Composite; Fundamental characteristics of implants - biocompatibility, bioactivity, biodegradability; Basics of drug delivery; Basics of tissue engineering. Biomaterial characterization techniques - Rheology, Atomic Force Microscopy, Electron Microscopy, Transmission Electron Microscopy Fourier Transform Infrared Spectroscopy.

BT	Biotechnology

Section 1: Engineering Mathematics

Linear Algebra: Matrices and determinants; Systems of linear equations; Eigen values and Eigen vectors.

Calculus: Limits, continuity and differentiability; Partial derivatives, maxima and minima; Sequences and series; Test for convergence.

Differential Equations: Linear and nonlinear first order ODEs, higher order ODEs with constant coefficients; Cauchy's and Euler's equations; Laplace transforms.

Probability and Statistics: Mean, median, mode and standard deviation; Random variables; Poisson, normal and binomial distributions; Correlation and regression analysis.

Numerical Methods: Solution of linear and nonlinear algebraic equations; Integration by trapezoidal and Simpson's rule; Single step method for differential equations.

Section 2: General Biology

Biochemistry: Biomolecules - structure and function; Biological membranes - structure, membrane channels and pumps, molecular motors, action potential and transport processes; Basic concepts and regulation of metabolism of carbohydrates, lipids, amino acids and nucleic acids; Photosynthesis, respiration and electron transport chain. Enzymes - Classification, catalytic and regulatory strategies; Enzyme kinetics - Michaelis-Menten equation; Enzyme inhibition - competitive, non-competitive and uncompetitive inhibition.

Microbiology: Bacterial classification and diversity; Microbial Ecology - microbes in marine, freshwater and terrestrial ecosystems; Microbial interactions; Viruses - structure and classification; Methods in microbiology; Microbial growth and nutrition; Nitrogen fixation; Microbial diseases and host-pathogen interactions; Antibiotics and antimicrobial resistance.

Immunology: Innate and adaptive immunity, humoral and cell mediated immunity; Antibody structure and function; Molecular basis of antibody diversity; T cell and B cell development; Antigen-antibody reaction; Complement; Primary and secondary lymphoid organs; Major histocompatibility complex (MHC); Antigen processing and presentation; Polyclonal and monoclonal antibody; Regulation of immune response; Immune tolerance; Hypersensitivity; Autoimmunity; Graft versus host reaction; Immunization and vaccines.

Section 3: Genetics, Cellular and Molecular Biology

Genetics and Evolutionary Biology: Mendelian inheritance; Gene interaction; Complementation; Linkage, recombination and chromosome mapping; Extra chromosomal inheritance; Microbial genetics - transformation, transduction and conjugation; Horizontal gene transfer and transposable elements; Chromosomal variation; Genetic disorders; Population genetics; Epigenetics; Selection and inheritance; Adaptive and neutral evolution; Genetic drift; Species and speciation.

Cell Biology: Prokaryotic and eukaryotic cell structure; Cell cycle and cell growth control; Cell-cell communication; Cell signaling and signal transduction; Post-translational modifications; Protein trafficking; Cell death and autophagy; Extra-cellular matrix.

Molecular Biology: Molecular structure of genes and chromosomes; Mutations and mutagenesis; Regulation of gene expression; Nucleic acid - replication, transcription, splicing, translation and their regulatory mechanisms; Non-coding and micro RNA; RNA interference; DNA damage and repair.

Section 4: Fundamentals of Biological Engineering

Engineering principles applied to biological systems: Material and energy balances for reactive and non-reactive systems; Recycle, bypass and purge processes; Stoichiometry of growth and product formation; Degree of reduction, electron balance, theoretical oxygen demand.

Classical thermodynamics and Bioenergetics: Laws of thermodynamics; Solution thermodynamics; Phase equilibria, reaction equilibria; Ligand binding; Membrane potential; Energetics of metabolic pathways, oxidation and reduction reactions.

Transport Processes: Newtonian and non-Newtonian fluids, fluid flow - laminar and turbulent; Mixing in bioreactors, mixing time; Molecular diffusion and film theory; Oxygen transfer and uptake in bioreactor, k_La and its measurement; Conductive and convective heat transfer, LMTD, overall heat transfer coefficient; Heat exchangers.

Section 5: Bioprocess Engineering and Process Biotechnology

Bioreaction engineering: Rate law, zero and first order kinetics; Ideal reactors - batch, mixed flow and plug flow; Enzyme immobilization, diffusion effects - Thiele modulus, effectiveness factor, Damkoehler number; Kinetics of cell growth, substrate utilization and product formation; Structured and unstructured models; Batch, fed-batch and continuous processes; Microbial and enzyme reactors; Optimization and scale up.

Upstream and Downstream Processing: Media formulation and optimization; Sterilization of air and media; Filtration - membrane filtration, ultrafiltration; Centrifugation - high speed and ultra; Cell disruption; Principles of chromatography - ion exchange, gel filtration, hydrophobic interaction, affinity, GC, HPLC and FPLC; Extraction, adsorption and drying.

Instrumentation and Process Control: Pressure, temperature and flow measurement devices; Valves; First order and second order systems; Feedback and feed forward control; Types of controllers – proportional, derivative and integral control, tuning of controllers.

Section 6: Plant, Animal and Microbial Biotechnology

Plants: Totipotency; Regeneration of plants; Plant growth regulators and elicitors; Tissue culture and cell suspension culture system - methodology, kinetics of growth and nutrient optimization; Production of secondary metabolites; Hairy root culture; Plant products of industrial importance; Artificial seeds; Somaclonal variation; Protoplast, protoplast fusion - somatic hybrid and cybrid;

Transgenic plants - direct and indirect methods of gene transfer techniques; Selection marker and reporter gene; Plastid transformation.

Animals: Culture media composition and growth conditions; Animal cell and tissue preservation; Anchorage and non-anchorage dependent cell culture; Kinetics of cell growth; Micro & macro-carrier culture; Hybridoma technology; Stem cell technology; Animal cloning; Transgenic animals; Knock-out and knock-in animals.

Microbes: Production of biomass and primary/secondary metabolites - Biofuels, bioplastics, industrial enzymes, antibiotics; Large scale production and purification of recombinant proteins and metabolites; Clinical-, food- and industrial- microbiology; Screening strategies for new products.

Section 7: Recombinant DNA technology and Other Tools in Biotechnology

Recombinant DNA technology: Restriction and modification enzymes; Vectors - plasmids, bacteriophage and other viral vectors, cosmids, Ti plasmid, bacterial and yeast artificial chromosomes; Expression vectors; cDNA and genomic DNA library; Gene isolation and cloning, strategies for production of recombinant proteins; Transposons and gene targeting;

Molecular tools: Polymerase chain reaction; DNA/RNA labelling and sequencing; Southern and northern blotting; In-situ hybridization; DNA fingerprinting, RAPD, RFLP; Site-directed mutagenesis; Gene transfer technologies; CRISPR-Cas; Biosensing and biosensors.

Analytical tools: Principles of microscopy - light, electron, fluorescent and confocal; Principles of spectroscopy - UV, visible, CD, IR, fluorescence, FT-IR, MS, NMR; Electrophoresis; Micro-arrays; Enzymatic assays; Immunoassays - ELISA, RIA, immunohistochemistry; immunoblotting; Flow cytometry; Whole genome and ChIP sequencing.

Computational tools: Bioinformatics resources and search tools; Sequence and structure databases; Sequence analysis - sequence file formats, scoring matrices, alignment, phylogeny; Genomics, proteomics, metabolomics; Gene prediction; Functional annotation; Secondary structure and 3D structure prediction; Knowledge discovery in biochemical databases; Metagenomics; Metabolic engineering and systems biology.

CE	Civil Engineering

Section 1: Engineering Mathematics

Linear Algebra: Matrix algebra; Systems of linear equations; Eigen values and Eigen vectors.

Calculus: Functions of single variable; Limit, continuity and differentiability; Mean value theorems, local maxima and minima; Taylor series; Evaluation of definite and indefinite integrals, application of definite integral to obtain area and volume; Partial derivatives; Total derivative; Gradient, Divergence and Curl, Vector identities; Directional derivatives; Line, Surface and Volume integrals.

Ordinary Differential Equation (ODE): First order (linear and non-linear) equations; higher order linear equations with constant coefficients; Euler-Cauchy equations; initial and boundary value problems.

Partial Differential Equation (PDE): Fourier series; separation of variables; solutions of one-dimensional diffusion equation; first and second order one-dimensional wave equation and two-dimensional Laplace equation.

Probability and Statistics: Sampling theorems; Conditional probability; Descriptive statistics – Mean, median, mode and standard deviation; Random Variables – Discrete and Continuous, Poisson and Normal Distribution; Linear regression.

Numerical Methods: Error analysis. Numerical solutions of linear and non-linear algebraic equations; Newton's and Lagrange polynomials; numerical differentiation; Integration by trapezoidal and Simpson's rule; Single and multi-step methods for first order differential equations.

Section 2: Structural Engineering

Engineering Mechanics: System of forces, free-body diagrams, equilibrium equations; Internal forces in structures; Frictions and its applications; Centre of mass; Free Vibrations of undamped SDOF system.

Solid Mechanics: Bending moment and shear force in statically determinate beams; Simple stress and strain relationships; Simple bending theory, flexural and shear stresses, shear centre; Uniform torsion, Transformation of stress; buckling of column, combined and direct bending stresses.

Structural Analysis: Statically determinate and indeterminate structures by force/ energy methods; Method of superposition; Analysis of trusses, arches, beams, cables and frames; Displacement methods: Slope deflection and moment distribution methods; Influence lines; Stiffness and flexibility methods of structural analysis.

Construction Materials and Management: Construction Materials: Structural Steel – Composition, material properties and behaviour; Concrete - Constituents, mix design, short-term and long-term properties. Construction Management: Types of construction projects; Project planning and network analysis - PERT and CPM; Cost estimation.

Concrete Structures: Working stress and Limit state design concepts; Design of beams, slabs, columns; Bond and development length; Prestressed concrete beams.

Steel Structures: Working stress and Limit state design concepts; Design of tension and compression members, beams and beam- columns, column bases; Connections - simple and eccentric, beam-column connections, plate girders and trusses; Concept of plastic analysis -beams and frames.

Section 3: Geotechnical Engineering

Soil Mechanics: Three-phase system and phase relationships, index properties; Unified and Indian standard soil classification system; Permeability - one dimensional flow, Seepage through soils – two - dimensional flow, flow nets, uplift pressure, piping, capillarity, seepage force; Principle of effective stress and quicksand condition; Compaction of soils; One- dimensional consolidation, time rate of consolidation; Shear Strength, Mohr's circle, effective and total shear strength parameters, Stress-Strain characteristics of clays and sand; Stress paths.

Foundation Engineering: Sub-surface investigations - Drilling bore holes, sampling, plate load test, standard penetration and cone penetration tests; Earth pressure theories - Rankine and Coulomb; Stability of slopes – Finite and infinite slopes, Bishop's method; Stress distribution in soils – Boussinesq's theory; Pressure bulbs, Shallow foundations – Terzaghi's and Meyerhoff's bearing capacity theories, effect of water table; Combined footing and raft foundation; Contact pressure; Settlement analysis in sands and clays; Deep foundations – dynamic and static formulae, Axial load capacity of piles in sands and clays, pile load test, pile under lateral loading, pile group efficiency, negative skin friction.

Section 4: Water Resources Engineering

Fluid Mechanics: Properties of fluids, fluid statics; Continuity, momentum and energy equations and their applications; Potential flow, Laminar and turbulent flow; Flow in pipes, pipe networks; Concept of boundary layer and its growth; Concept of lift and drag.

Hydraulics: Forces on immersed bodies; Flow measurement in channels and pipes; Dimensional analysis and hydraulic similitude; Channel Hydraulics - Energy-depth relationships, specific energy, critical flow, hydraulic jump, uniform flow, gradually varied flow and water surface profiles.

Hydrology: Hydrologic cycle, precipitation, evaporation, evapo-transpiration, watershed, infiltration, unit hydrographs, hydrograph analysis, reservoir capacity, flood estimation and routing, surface run-off models, ground water hydrology - steady state well hydraulics and aquifers; Application of Darcy's Law.

Irrigation: Types of irrigation systems and methods; Crop water requirements - Duty, delta, evapo-transpiration; Gravity Dams and Spillways; Lined and unlined canals, Design of weirs on permeable foundation; cross drainage structures.

Section 5: Environmental Engineering

Water and Waste Water Quality and Treatment: Basics of water quality standards – Physical, chemical and biological parameters; Water quality index; Unit processes and operations; Water requirement; Water distribution system; Drinking water treatment.

Sewerage system design, quantity of domestic wastewater, primary and secondary treatment. Effluent discharge standards; Sludge disposal; Reuse of treated sewage for different applications.

Air Pollution: Types of pollutants, their sources and impacts, air pollution control, air quality standards, Air quality Index and limits.

Municipal Solid Wastes: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal).

Section 6: Transportation Engineering

Transportation Infrastructure: Geometric design of highways - cross-sectional elements, sight distances, horizontal and vertical alignments.

Geometric design of railway Track – Speed and Cant.

Concept of airport runway length, calculations and corrections; taxiway and exit taxiway design.

Highway Pavements: Highway materials - desirable properties and tests; Desirable properties of bituminous paving mixes; Design factors for flexible and rigid pavements; Design of flexible and rigid pavement using IRC codes

Traffic Engineering: Traffic studies on flow and speed, peak hour factor, accident study, statistical analysis of traffic data; Microscopic and macroscopic parameters of traffic flow, fundamental relationships; Traffic signs; Signal design by Webster's method; Types of intersections; Highway capacity.

Section 7: Geomatics Engineering

Principles of surveying; Errors and their adjustment; Maps - scale, coordinate system; Distance and angle measurement - Levelling and trigonometric levelling; Traversing and triangulation survey; Total station; Horizontal and vertical curves.

Photogrammetry and Remote Sensing - Scale, flying height; Basics of remote sensing and GIS.

CH	Chemical Engineering

Section 1: Engineering Mathematics

Linear Algebra*:* Matrix algebra, Systems of linear equations, Eigen values and eigenvectors.

Calculus*:* Functions of single variable, Limit, continuity and differentiability, Taylor series, Mean value theorems, Evaluation of definite and improper integrals, Partial derivatives, Total derivative, Maxima and minima, Gradient, Divergence and Curl, Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

Differential equations*:* First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy's and Euler's equations, Initial and boundary value problems, Laplace transforms, Solutions of one dimensional heat and wave equations and Laplace equation.

Complex variables*:* Complex number, polar form of complex number, triangle inequality.

Probability and Statistics*:* Definitions of probability and sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Poisson, Normal and Binomial distributions, Linear regression analysis.

Numerical Methods*:* Numerical solutions of linear and non-linear algebraic equations. Integration by trapezoidal and Simpson's rule. Single and multi-step methods for numerical solution of differential equations.

Section 2: Process Calculations and Thermodynamics

Steady and unsteady state mass and energy balances including multiphase, multi-component, reacting and non-reacting systems. Use of tie components; recycle, bypass and purge calculations; Gibb's phase rule and degree of freedom analysis.

First and Second laws of thermodynamics. Applications of first law to close and open systems. Second law and Entropy. Thermodynamic properties of pure substances: Equation of State and residual properties, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibrium.

Section 3: Fluid Mechanics and Mechanical Operations

Fluid statics, surface tension, Newtonian and non-Newtonian fluids, transport properties, shell-balances including differential form of Bernoulli equation and energy balance, equation of continuity, equation of motion, equation of mechanical energy, Macroscopic friction factors, dimensional analysis and similitude, flow through pipeline systems, velocity profiles, flow meters, pumps and compressors, elementary boundary layer theory, flow past immersed bodies including packed and fluidized beds, Turbulent flow: fluctuating velocity, universal velocity profile and pressure drop.

Particle size and shape, particle size distribution, size reduction and classification of solid particles; free and hindered settling; centrifuge and cyclones; thickening and classification, filtration, agitation and mixing; conveying of solids.

Section 4: Heat Transfer

Equation of energy, steady and unsteady heat conduction, convection and radiation, thermal boundary layer and heat transfer coefficients, boiling, condensation and evaporation; types of heat exchangers and evaporators and their process calculations; design of double pipe, shell and tube heat exchangers, and single and multiple effect evaporators.

Section 5: Mass Transfer

Fick's laws, molecular diffusion in fluids, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass transfer analogies; stage-wise and continuous contacting and stage efficiencies; HTU & NTU concepts; design and operation of equipment for distillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification and adsorption, membrane separations(micro-filtration, ultra-filtration, nano-filtration and reverse osmosis).

Section 6: Chemical Reaction Engineering

Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, kinetics of enzyme reactions (Michaelis-Menten and Monod models), non-ideal reactors; residence time distribution, single parameter model; non-isothermal reactors; kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis; rate and performance equations for catalyst deactivation

Section 7: Instrumentation and Process Control

Measurement of process variables; sensors and transducers; P&ID equipment symbols; process modeling and linearization, transfer functions and dynamic responses of various systems, systems with inverse response, process reaction curve, controller modes (P, PI, and PID); control valves;

transducer dynamics; analysis of closed loop systems including stability, frequency response, controller tuning, cascade and feed forward control.

Section 8: Plant Design and Economics

Principles of process economics and cost estimation including depreciation and total annualized cost, cost indices, rate of return, payback period, discounted cash flow, optimization in process design and sizing of chemical engineering equipments such as heat exchangers and multistage contactors.

Section 9: Chemical Technology

Inorganic chemical industries (sulfuric acid, phosphoric acid, chlor-alkali industry), fertilizers (Ammonia, Urea, SSP and TSP); natural products industries (Pulp and Paper, Sugar, Oil, and Fats); petroleum refining and petrochemicals; polymerization industries (polyethylene, polypropylene, PVC and polyester synthetic fibers).

CS Computer Science and Information Technology

Section 1: Engineering Mathematics

Discrete Mathematics: Propositional and first order logic. Sets, relations, functions, partial orders and lattices. Monoids, Groups. Graphs: connectivity, matching, coloring. Combinatorics: counting, recurrence relations, generating functions.

Linear Algebra: Matrices, determinants, system of linear equations, eigenvalues and eigenvectors, LU decomposition.

Calculus: Limits, continuity and differentiability. Maxima and minima. Mean value theorem. Integration.

Probability and Statistics: Random variables. Uniform, normal, exponential, poisson and binomial distributions. Mean, median, mode and standard deviation. Conditional probability and Bayes theorem.

Computer Science and Information Technology

Section 2: Digital Logic

Boolean algebra. Combinational and sequential circuits. Minimization. Number representations and computer arithmetic (fixed and floating point).

Section 3: Computer Organization and Architecture

Machine instructions and addressing modes. ALU, data-path and control unit. Instruction pipelining, pipeline hazards. Memory hierarchy: cache, main memory and secondary storage; I/O interface (interrupt and DMA mode).

Section 4: Programming and Data Structures

Programming in C. Recursion. Arrays, stacks, queues, linked lists, trees, binary search trees, binary heaps, graphs.

Section 5: Algorithms

Searching, sorting, hashing. Asymptotic worst case time and space complexity. Algorithm design techniques: greedy, dynamic programming and divide-and-conquer. Graph traversals, minimum spanning trees, shortest paths

Section 6: Theory of Computation

Regular expressions and finite automata. Context-free grammars and push-down automata. Regular and contex-free languages, pumping lemma. Turing machines and undecidability.

Section 7: Compiler Design

Lexical analysis, parsing, syntax-directed translation. Runtime environments. Intermediate code generation. Local optimisation, Data flow analyses: constant propagation, liveness analysis, common subexpression elimination.

Section 8: Operating System

System calls, processes, threads, inter-process communication, concurrency and synchronization. Deadlock. CPU and I/O scheduling. Memory management and virtual memory. File systems.

Section 9: Databases

ER-model. Relational model: relational algebra, tuple calculus, SQL. Integrity constraints, normal forms. File organization, indexing (e.g., B and B+ trees). Transactions and concurrency control.

Section 10: Computer Networks

Concept of layering: OSI and TCP/IP Protocol Stacks; Basics of packet, circuit and virtual circuit-switching; Data link layer: framing, error detection, Medium Access Control, Ethernet bridging; Routing protocols: shortest path, flooding, distance vector and link state routing; Fragmentation and IP addressing, IPv4, CIDR notation, Basics of IP support protocols (ARP, DHCP, ICMP), Network Address Translation (NAT); Transport layer: flow control and congestion control, UDP, TCP, sockets; Application layer protocols: DNS, SMTP, HTTP, FTP, Email.

CY	Chemistry

Section 1: Physical Chemistry

Structure: Postulates of quantum mechanics. Operators. Time dependent and time independent Schrödinger equations. Born interpretation. Dirac bra-ket notation. Particle in a box: infinite and finite square wells; concept of tunnelling; particle in 1D, 2D and 3D-box; applications. Harmonic oscillator: harmonic and anharmonic potentials; hermite polynomials. Rotational motion: Angular momentum operators, Rigid rotor. Hydrogen and hydrogen-like atoms : atomic orbitals; radial distribution function. Multi-electron atoms: orbital approximation; electron spin; Pauli exclusion principle; slater determinants. Approximation Methods: Variation method and secular determinants; first order perturbation techniques. Atomic units. Molecular structure and Chemical bonding: Born-Oppenheimer approximation; Valence bond theory and linear combination of atomic orbitals – molecular orbital (LCAO-MO) theory. Hybrid orbitals. Applications of LCAO-MO theory to H_2^+, H_2; orbital theory (MOT) of homo- and heteronuclear diatomic molecules. Hückel approximation and its application to annular π – electron systems.

Group theory: Symmetry elements and operations; Point groups and character tables; Internal coordinates and vibrational modes; symmetry adapted linear combination of atomic orbitals (LCAO-MO); construction of hybrid orbitals using symmetry aspects.

Spectroscopy: Atomic spectroscopy; Russell-Saunders coupling; Term symbols and spectral details; origin of selection rules. Rotational, vibrational, electronic and Raman spectroscopy of diatomic and polyatomic molecules. Line broadening. Einstein's coefficients. Relationship of transition moment integral with molar extinction coefficient and oscillator strength. Basic principles of nuclear magnetic resonance: gyromagnetic ratio; chemical shift, nuclear coupling.

Equilibrium: Laws of thermodynamics. Standard states. Thermochemistry. Thermodynamic functions and their relationships: Gibbs-Helmholtz and Maxwell relations, Gibbs-Duhem equation, van't Hoff equation. Criteria of spontaneity and equilibrium. Absolute entropy. Partial molar quantities. Thermodynamics of mixing. Chemical potential. Fugacity, activity and activity coefficients. Ideal and Non-ideal solutions, Raoult's Law and Henry's Law, Chemical equilibria. Dependence of equilibrium constant on temperature and pressure. Ionic mobility and conductivity. Debye-Hückel limiting law. Debye-Hückel-Onsager equation. Standard electrode potentials and electrochemical cells. Nernst Equation and its application, relationship between Electrode potential and thermodynamic quantities, Potentiometric and conductometric titrations. Phase rule. Clausius-Clapeyron equation. Phase diagram of one component systems: CO_2, H_2O, S; two component systems: liquid- vapour, liquid-liquid and solid-liquid systems. Fractional distillation. Azeotropes and eutectics. Statistical thermodynamics: microcanonical, canonical and grand canonical ensembles, Boltzmann distribution, partition functions and thermodynamic properties.

Kinetics (Topic have been rearranged): Elementary, parallel, opposing and consecutive reactions. Steady state approximation. Mechanisms of complex reactions. Unimolecular reactions. Potential energy surfaces and classical trajectories, Concept of Saddle points, Transition state theory: Eyring equation, thermodynamic aspects. Kinetics of polymerization. Catalysis concepts and enzyme catalysis. Kinetic isotope effects. Fast reaction kinetics: relaxation and flow methods. Diffusion controlled reactions. Kinetics of photochemical and photophysical processes.

Surfaces and Interfaces: Physisorption and chemisorption. Langmuir, Freundlich and Brunauer–Emmett–Teller (BET) isotherms. Surface catalysis: Langmuir-Hinshelwood mechanism. Surface tension, viscosity. Self-assembly. Physical chemistry of colloids, micelles and macromolecules.

Section 2: Inorganic Chemistry

Main Group Elements: Hydrides, halides, oxides, oxoacids, nitrides, sulfides – shapes and reactivity. Structure and bonding of boranes, carboranes, silicones, silicates, boron nitride, borazines and phosphazenes. Allotropes of carbon, phosphorous and sulphur. Industrial synthesis of compounds of main group elements. Chemistry of noble gases, pseudohalogens, and interhalogen compounds. Acid-base concepts and principles (Lewis, Brønsted, HSAB and acid-base catalysis).

Transition Elements: Coordination chemistry – structure and isomerism, theories of bonding (VBT, CFT, and MOT). Energy level diagrams in various crystal fields, CFSE, applications of CFT, Jahn-Teller distortion. Electronic spectra of transition metal complexes: spectroscopic term symbols, selection rules, Orgel and Tanabe-Sugano diagrams, nephelauxetic effect and Racah parameter, charge-transfer spectra. Magnetic properties of transition metal complexes. Ray-Dutt and Bailar twists, Reaction mechanisms: kinetic and thermodynamic stability, substitution and redox reactions. Metal-metal multiple bond.

Lanthanides and Actinides: Recovery. Periodic properties, spectra and magnetic properties.

Organometallics: 18-Electron rule; metal-alkyl, metal-carbonyl, metal-olefin and metal- carbene complexes and metallocenes. Fluxionality in organometallic complexes. Types of organometallic reactions. Homogeneous catalysis - Hydrogenation, hydroformylation, acetic acid synthesis, metathesis and olefin oxidation. Heterogeneous catalysis - Fischer- Tropsch reaction, Ziegler-Natta polymerization.

Radioactivity: Detection of radioactivity, Decay processes, half-life of radioactive elements, fission and fusion processes.

Bioinorganic Chemistry: Ion (Na^+ and K^+) transport, oxygen binding, transport and utilization, electron transfer reactions, nitrogen fixation, metalloenzymes containing magnesium, molybdenum, iron, cobalt, copper and zinc.

Solids: Crystal systems and lattices, Miller planes, crystal packing, crystal defects, Bragg's law, ionic crystals, structures of AX, AX_2, ABX_3 type compounds, spinels, band theory, metals and semiconductors.

Instrumental Methods of Analysis: UV-visible, fluorescence and FTIR spectrophotometry, NMR and ESR spectroscopy, mass spectrometry, atomic absorption spectroscopy, Mössbauer spectroscopy (Fe and Sn) and X-ray crystallography. Chromatography including GC and HPLC. Electroanalytical methods- polarography, cyclic voltammetry, ion-selective electrodes. Thermoanalytical methods.

Section 3: Organic Chemistry

Stereochemistry: Chirality and symmetry of organic molecules with or without chiral centres and determination of their absolute configurations. Relative stereochemistry in compounds having more than one stereogenic centre. Homotopic, enantiotopic and diastereotopic atoms, groups and faces. Stereoselective and stereospecific synthesis. Conformational analysis of acyclic and cyclic compounds. Geometrical isomerism and optical isomerism. Configurational and conformational effects, atropisomerism, and neighbouring group participation on reactivity and selectivity/specificity.

Reaction Mechanisms: Basic mechanistic concepts – kinetic versus thermodynamic control, Hammond's postulate and Curtin-Hammett principle. Methods of determining reaction mechanisms through kinetics, identification of products, intermediates and isotopic labelling. Linear free-energy relationship – Hammett and Taft equations. Nucleophilic and electrophilic substitution reactions (both aromatic and aliphatic). Addition reactions to carbon-carbon and carbon-heteroatom (N and O) multiple bonds. Elimination reactions. Reactive intermediates – carbocations, carbanions, carbenes, nitrenes, arynes and free radicals. Molecular rearrangements.

Organic Synthesis: Synthesis, reactions, mechanisms and selectivity involving the following classes of compounds – alkenes, alkynes, arenes, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, nitriles, halides, nitro compounds, amines and amides. Uses of Mg, Li, Cu, B, Zn, P, S, Sn and Si based reagents in organic synthesis. Carbon-carbon bond formation through coupling reactions - Heck, Suzuki, Stille, Sonogoshira, Negishi, Kumada, Hiyama, Tsuji-Trost, olefin metathesis and McMurry. Concepts of multistep synthesis - retrosynthetic analysis, strategic disconnections, synthons and synthetic equivalents. Atom economy and Green Chemistry, Umpolung reactivity – formyl and acyl anion equivalents. Selectivity in organic synthesis – chemo-, regio- and stereoselectivity. Protection and deprotection of functional groups. Concepts of asymmetric synthesis – resolution (including enzymatic), desymmetrization and use of chiral auxiliaries, organocatalysis. Carbon-carbon and carbon-heteroatom bond forming reactions through enolates (including boron enolates), enamines and silyl enol ethers. Stereoselective addition to C=O groups (Cram, Prelog and Felkin-Anh models).

Pericyclic Reactions and Photochemistry: Electrocyclic, cycloaddition and sigmatropic reactions. Orbital correlations - FMO and PMO treatments, Woodward-Hoffmann rule. Photochemistry of alkenes, arenes and carbonyl compounds. Photooxidation and photoreduction. Di-π-methane rearrangement, Barton-McCombie reaction, Norrish type-I and II cleavage reaction.

Heterocyclic Compounds: Structure, preparation, properties and reactions of furan, pyrrole, thiophene, pyridine, indole, quinoline and isoquinoline.

Biomolecules: Structure, properties and reactions of mono- and di-saccharides, physicochemical properties of amino acids, chemical synthesis of peptides, chemical structure determination of peptides and proteins, structural features of proteins, nucleic acids, lipids, steroids, terpenoids, carotenoids, and alkaloids.

Experimental techniques in organic chemistry: Optical rotation (polarimetry). Applications of various chromatographic techniques such as thin-layer, column, HPLC and GC. Applications of UV-visible, IR, NMR and Mass spectrometry in the structural determination of organic molecules.

EC	Electronics and Communications

Section 1: Engineering Mathematics

Linear Algebra: Vector space, basis, linear dependence and independence, matrix algebra, eigenvalues and eigenvectors, rank, solution of linear equations- existence and uniqueness.

Calculus: Mean value theorems, theorems of integral calculus, evaluation of definite and improper integrals, partial derivatives, maxima and minima, multiple integrals, line, surface and volume integrals, Taylor series.

Differential Equations: First order equations (linear and nonlinear), higher order linear differential equations, Cauchy's and Euler's equations, methods of solution using variation of parameters, complementary function and particular integral, partial differential equations, variable separable method, initial and boundary value problems.

Vector Analysis: Vectors in plane and space, vector operations, gradient, divergence and curl, Gauss's, Green's and Stokes' theorems.

Complex Analysis: Analytic functions, Cauchy's integral theorem, Cauchy's integral formula, sequences, series, convergence tests, Taylor and Laurent series, residue theorem.

Probability and Statistics: Mean, median, mode, standard deviation, combinatorial probability, probability distributions, binomial distribution, Poisson distribution, exponential distribution, normal distribution, joint and conditional probability.

Section 2: Networks, Signals and Systems

Circuit analysis: Node and mesh analysis, superposition, Thevenin's theorem, Norton's theorem, reciprocity. Sinusoidal steady state analysis: phasors, complex power, maximum power transfer. Time and frequency domain analysis of linear circuits: RL, RC and RLC circuits, solution of network equations using Laplace transform.

Linear 2-port network parameters, wye-delta transformation.

Continuous-time signals: Fourier series and Fourier transform, sampling theorem and applications.

Discrete-time signals: DTFT, DFT, z-transform, discrete-time processing of continuous-time signals. LTI systems: definition and properties, causality, stability, impulse response, convolution, poles and zeroes, frequency response, group delay, phase delay.

Section 3: Electronic Devices

Energy bands in intrinsic and extrinsic semiconductors, equilibrium carrier concentration, direct and indirect band-gap semiconductors.

Carrier transport: diffusion current, drift current, mobility and resistivity, generation and recombination of carriers, Poisson and continuity equations.

P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photo diode and solar cell.

Section 4: Analog Circuits

Diode circuits: clipping, clamping and rectifiers.

BJT and MOSFET amplifiers: biasing, ac coupling, small signal analysis, frequency response.

Current mirrors and differential amplifiers.

Op-amp circuits: Amplifiers, summers, differentiators, integrators, active filters, Schmitt triggers and oscillators.

Section 5: Digital Circuits

Number representations: binary, integer and floating-point- numbers. Combinatorial circuits: Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates and their static CMOS implementations, arithmetic circuits, code converters, multiplexers, decoders.

Sequential circuits: latches and flip-flops, counters, shift-registers, finite state machines, propagation delay, setup and hold time, critical path delay.

Data converters: sample and hold circuits, ADCs and DACs.

Semiconductor memories: ROM, SRAM, DRAM.

Computer organization: Machine instructions and addressing modes, ALU, data-path and control unit, instruction pipelining.

Section 6: Control Systems

Basic control system components; Feedback principle; Transfer function; Block diagram representation; Signal flow graph; Transient and steady-state analysis of LTI systems; Frequency response; Routh-Hurwitz and Nyquist stability criteria; Bode and root-locus plots; Lag, lead and lag-lead compensation; State variable model and solution of state equation of LTI systems.

Section 7: Communications

Random processes: autocorrelation and power spectral density, properties of white noise, filtering of random signals through LTI systems.

Analog communications: amplitude modulation and demodulation, angle modulation and demodulation, spectra of AM and FM, superheterodyne receivers.

Information theory: entropy, mutual information and channel capacity theorem.

Digital communications: PCM, DPCM, digital modulation schemes (ASK, PSK, FSK, QAM), bandwidth, inter-symbol interference, MAP, ML detection, matched filter receiver, SNR and BER.

Fundamentals of error correction, Hamming codes, CRC.

Section 8: Electromagnetics

Maxwell's equations: differential and integral forms and their interpretation, boundary conditions, wave equation, Poynting vector.

Plane waves and properties: reflection and refraction, polarization, phase and group velocity, propagation through various media, skin depth.

Transmission lines: equations, characteristic impedance, impedance matching, impedance transformation, S-parameters, Smith chart.

Rectangular and circular waveguides, light propagation in optical fibers, dipole and monopole antennas, linear antenna arrays.

EE Electrical Engineering

Section 1: Engineering Mathematics

Linear Algebra: Matrix Algebra, Systems of linear equations, Eigenvalues, Eigenvectors.

Calculus: Mean value theorems, Theorems of integral calculus, Evaluation of definite and improper integrals, Partial Derivatives, Maxima and minima, Multiple integrals, Fourier series, Vector identities, Directional derivatives, Line integral, Surface integral, Volume integral, Stokes's theorem, Gauss's theorem, Divergence theorem, Green's theorem.

Differential equations: First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Method of variation of parameters, Cauchy's equation, Euler's equation, Initial and boundary value problems, Partial Differential Equations, Method of separation of variables.

Complex variables: Analytic functions, Cauchy's integral theorem, Cauchy's integral formula, Taylor series, Laurent series, Residue theorem, Solution integrals.

Probability and Statistics: Sampling theorems, Conditional probability, Mean, Median, Mode, Standard Deviation, Random variables, Discrete and Continuous distributions, Poisson distribution, Normal distribution, Binomial distribution, Correlation analysis, Regression analysis.

Section 2: Electric circuits

Network elements: ideal voltage and current sources, dependent sources, R, L, C, M elements; Network solution methods: KCL, KVL, Node and Mesh analysis; Network Theorems: Thevenin's, Norton's, Superposition and Maximum Power Transfer theorem; Transient response of dc and ac networks, sinusoidal steady-state analysis, resonance, two port networks, balanced three phase circuits, star-delta transformation, complex power and power

factor in ac circuits.

Section 3: Electromagnetic Fields

Coulomb's Law, Electric Field Intensity, Electric Flux Density, Gauss's Law, Divergence, Electric

field and potential due to point, line, plane and spherical charge distributions, Effect of dielectric medium, Capacitance of simple configurations, Biot-Savart's law, Ampere's law,Curl, Faraday's law, Lorentz force, Inductance, Magnetomotive force, Reluctance, Magnetic circuits, Self and Mutual inductance of simple configurations.

Section 4: Signals and Systems

Representation of continuous and discrete time signals, shifting and scaling properties, linear time invariant and causal systems, Fourier series representation of continuous and discrete time periodic signals, sampling theorem, Applications of Fourier Transform for continuous and discrete time signals, Laplace Transform and Z transform. R.M.S. value, average value calculation for any general periodic waveform

Section 5: Electrical Machines

Single phase transformer: equivalent circuit, phasor diagram, open circuit and short circuit tests, regulation and efficiency; Three-phase transformers: connections, vector groups, parallel operation; Auto-transformer, Electromechanical energy conversion principles; DC machines: separately excited, series and shunt, motoring and generating mode of operation and their characteristics, speed control of dc motors; Three-phase induction machines: principle of operation, types, performance, torque-speed characteristics, no-load and blocked-rotor tests, equivalent circuit, starting and speed control; Operating principle of single-phase induction motors; Synchronous machines: cylindrical and salient pole machines, performance and characteristics, regulation and parallel operation of generators, starting of synchronous motors; Types of losses and efficiency calculations of electric machines

Section 6: Power Systems

Basic concepts of electrical power generation, ac and dc transmission concepts, Models and performance of transmission lines and cables, Economic Load Dispatch (with and without considering transmission losses), Series and shunt compensation, Electric field distribution and insulators, Distribution systems, Per-unit quantities, Bus admittance matrix, Gauss- Seidel and Newton-Raphson load flow methods, Voltage and Frequency control, Power factor correction, Symmetrical components, Symmetrical and unsymmetrical fault analysis, Principles of over-current, differential, directional and distance protection; Circuit breakers, System stability concepts, Equal area criterion.

Section 7: Control Systems

Mathematical modeling and representation of systems, Feedback principle, transfer function, Block diagrams and Signal flow graphs, Transient and Steady-state analysis of linear time invariant systems, Stability analysis using Routh-Hurwitz and Nyquist criteria, Bode plots, Root loci, Lag, Lead and Lead-Lag compensators; P, PI and PID controllers; State space model, Solution of state equations of LTI systems

Section 8: Electrical and Electronic Measurements

Bridges and Potentiometers, Measurement of voltage, current, power, energy and power factor; Instrument transformers, Digital voltmeters and multimeters, Phase, Time and Frequency measurement; Oscilloscopes, Error analysis.

Section 9: Analog and Digital Electronics

Simple diode circuits: clipping, clamping, rectifiers; Amplifiers: biasing, equivalent circuit and frequency response; oscillators and feedback amplifiers; operational amplifiers: characteristics and applications; single stage active filters, Active Filters: Sallen Key, Butterwoth, VCOs and timers, combinatorial and sequential logic circuits, multiplexers, demultiplexers, Schmitt triggers, sample and hold circuits, A/D and D/A converters.

Section 10: Power Electronics

Static V-I characteristics and firing/gating circuits for Thyristor, MOSFET, IGBT; DC to DC conversion: Buck, Boost and Buck-Boost Converters; Single and three-phase configuration of uncontrolled rectifiers; Voltage and Current commutated Thyristor based converters; Bidirectional ac to dc voltage source converters; Magnitude and Phase of line current harmonics for uncontrolled and thyristor based converters; Power factor and Distortion Factor of ac to dc converters; Single-phase and three-phase voltage and current source inverters, sinusoidal pulse width modulation.

ES Environmental Science and Engineering

Section 1: Mathematics Foundation

Linear Algebra: Determinants and matrices, Systems of linear equations, Eigenvalues and eigenvectors.

Calculus: Functions, Limit, Continuity, Differentiability, Local maxima and minima, Taylor series, Tests for convergence, Definite and indefinite integrals, Application of definite integral to obtain area and volume, Partial and total derivatives.

Differential Equations: Linear and non-linear first order ordinary differential equations (ODE), Higher order linear ODEs with constant coefficients, Cauchy's and Euler's equations, Laplace transform and its application in solving linear ODEs.

Probability and Statistics: Descriptive statistics, Measurement of central tendency, Dispersion, Skewness and kurtosis, Probability concepts, Conditional probability, Bayes theorem, Risk and reliability, Probability distributions, Correlation, Single and multiple regression models, Hypothesis testing (t-test, F-test, chi-square test).

Section 2: Environmental Chemistry

Fundamentals of Environmental Chemistry: Covalent and ionic bonding; Chemical equations, concentration and activity; Structure and chemistry of organic molecules; Radioactivity of elements; Chemical equilibria; Thermodynamics and kinetics of chemical reactions.

Principles of water chemistry: Water quality parameters and their measurement; Acid-base equilibria; Buffer solution; Carbonate system; Solubility of gases in water; Complexation, precipitation, and redox reactions; Inorganic and organic contaminants in water and their speciation.

Soil chemistry; Organic matter, nitrogen, phosphorous, potassium, cation exchange capacity, base saturation, and sodium absorption ratio.

Atmospheric Chemistry: Composition of the atmosphere; Reactivity of trace substances in the atmosphere; Urban atmosphere—smog and particulate pollution; Chemistry of ozone formation; Chemistry of stratosphere.

Section 3: Environmental Microbiology

Prokaryotic and eukaryotic microorganisms; Characteristics of diverse groups of microorganisms; Classification of microorganisms; Microbial diversity; Plant-microbe and soil-microbe interactions; Role of microorganisms in wastewater treatment, bioremediation and biogeochemical cycling.

Cell chemistry and cell biology: Structure of proteins, nucleic acid (DNA & RNA), lipids and polysaccharides; Bonds in biomolecules; Stereoisomerism in biomolecules; Structure of cell; Structure and function of cytoplasmic membrane, cell wall, outer membrane, glycocalyx, chromosomes, endospores, storage products, mitochondria and chloroplasts.

Microbial metabolism: Anabolism and catabolism; Phosphorylation; Glycolysis; TCA cycle; Electron transport chain; Fermentation; Anaerobic respiration; Energy balances; Enzymes and Enzyme kinetics.

Growth and control of microorganisms: Bacterial nutrition and growth; Specific growth rate and doubling time; Monod's model; Types of culture media; Batch and continuous culture; Effects of environmental factors on growth; Control of microbes using physical and chemical methods.

Microbiology and health: Pathogens and modes of transmission; Indicator organisms; Quantification of coliforms using MPN and membrane filtration techniques.

Section 4: Water Resources and Environmental Hydraulics

Global Water Resources: Structure, properties and distribution of water; Water quality; Threats to water resources; Water conservation.

Surface Water Resources: Hydrological cycle and water balance - precipitation, infiltration, evapotranspiration, runoff; Flow hydrographs; Unit hydrographs; Stage-discharge relationship; Reservoir capacity; Reservoir and channel routing; Surface run-off models; Surface water management; Rain water harvesting and storage.

Groundwater Resources: Geologic formations as aquifers; Vadose and saturated zones; Confined and unconfined aquifers and their parameters - porosity, permeability, transmissivity and storage coefficient; Darcy's law and applications; Steady state well hydraulics.

Environmental Hydraulics: Concepts of mechanics; Properties of fluids; Pressure measurement; Hydrostatic force on surfaces; Buoyancy and flotation; Laminar and turbulent flow; Flow through pipes; Pipe networks; Boundary layer theory; Forces on immersed bodies; Flow measurement in channels and pipes; Kinematics of flow; Continuity, momentum and energy equations; Channel hydraulics - specific energy, critical flow, hydraulic jump, rapid and gradually varied flow; Design of lined and unlined channels.

Section 5: Water & Wastewater Treatment and Management

Water and wastewater quality parameters; Eutrophication and thermal stratification in lakes; River pollution - Oxygen sag curve.

Water treatment methods - screening, sedimentation with and without coagulation, filtration, desalination, disinfection; Water distribution and storage

Point and non-point sources of wastewater; Population forecasting methods; Design of sewer and storm water sewers; Sewer appurtenances; Preliminary, primary, secondary and tertiary sewage treatment; Sludge generation, processing and disposal methods; Sewage farming.

Sources and characteristics of industrial effluents; Concept of Common Effluent Treatment Plants (CETP); Wastewater recycling and zero liquid discharge.

Kinetics and reactor design: Mass and energy balance, Order and rate of reactions, Batch reactors, Completely mixed flow reactors, Plug flow reactors.

Section 6: Air and Noise Pollution

Structure of the atmosphere; Natural and anthropogenic sources of pollution; Atmospheric sources, sinks, transport; Indoor air pollution; Effects on health and environment; Air pollution: gases and particulate matter; Air quality standards; Primary and secondary pollutants; Criteria pollutants, ambient and source standards, air quality indices, visibility.

Particulate pollutants: measurement and control methods; Control of particulate air pollutants using gravitational settling chambers, cyclone separators, wet collectors, fabric filters (Bag-house filter), electrostatic precipitators (ESP).

Gaseous Pollutants: Measurement and control methods; Control of gaseous contaminants: absorption, adsorption, condensation and combustion; Control of sulphur oxides, nitrogen oxides, carbon monoxide, and hydrocarbons; Vapour-liquid and vapour-solid equilibria; Diffusion, Fick's law and interfacial mass transfer.

Automotive emission controls, fuel quality, diesel particulate filters, catalytic convertors.

Air quality management: Point, line and area sources; Inventory; Influence of meteorology - wind rose diagrams, stability, mixing height, topography, dispersion modelling, monitoring.

Noise pollution: Sources; Health effects; Standards; Measurement and control methods.

Section 7: Solid and Hazardous Waste Management

Integrated solid waste management; Waste hierarchy; Rules and regulations for solid waste management in India.

Municipal solid waste management: Sources, generation, characteristics, collection and transportation, waste processing and disposal (including reuse options, biological methods, energy recovery processes and landfilling).

Hazardous waste management: Characteristics, generation, fate of materials in the environment, treatment and disposal.

Soil contamination and leaching of contaminants into groundwater.

Management of biomedical waste, plastic waste and E-waste: Sources, generation and characteristics; Waste management practices including storage, collection and transfer.

Section 8: Global and Regional Environmental Issues

Global effects of air pollution – Greenhouse gases, global warming, climate change, urban heat islands, acid rain, ozone hole.

Ecology and various ecosystems; Biodiversity; Factors influencing increase in population, energy consumption, and environmental degradation.

Section 9: Environmental Management and Sustainable Development

Environmental Management Systems; ISO14000 series; Environmental auditing: Environmental Impact Assessment; Life cycle assessment; Human health risk assessment

Environmental Law and Policy – Objectives; Polluter pays principle, Precautionary principle; The Water and Air Acts with amendments; The Environment (Protection) Act (EPA) 1986; National Green Tribunal Act, 2010; National Environment Policy; Principles of International Law and International treaties.

Energy and Environment: Energy sources – overview of resources and reserves; Renewable and non-renewable energy sources; Energy-Environment nexus.

Sustainable Development: Definition and concepts of sustainable development; Sustainable development goals; Hurdles to sustainability; Environment and economics

EY Ecology and Evolution

Section 1: Ecology

Fundamental concepts: Abiotic and biotic components; scales (population, species, community, ecosystems, biomes); niches and habitats.

Population ecology: Population growth rates (density dependent/independent); metapopulation ecology (colonization, persistence, extinction, patches, sources, sinks); age-structured populations.

Interactions: Types (mutualism, symbiosis, commensalism, competition, parasitism, predation, etc); ecophysiology (physiological adaptations to abiotic environment); prey-predator interactions (Lotka-Voltera equation etc)

Community ecology: Community assembly, organization and succession; species richness, evenness and diversity indices, species-area relationships; theory of island biogeography

Ecosystems structure and function: trophic levels and their interactions; nutrient cycles; primary and secondary productivity

Section 2: Evolution

History of Evolutionary thought: Lamarckism; Darwinism; Modern Synthesis

Fundamentals: Variation; heritability; natural selection; fitness and adaptation; types of selection (stabilizing, directional, disruptive)

Diversity of life: Origin and history of life on earth; diversity and classification of life; systems of classification (cladistics and phenetics)

Life history strategies: Allocation of resources; tradeoffs; r/K selection; semelparity and iteroparity

Interactions: Co-evolution (co-adaptations, arms race, Red Queen hypothesis, co-speciation); prey-predator interactions (mimicry, crypsis, etc)

Population and Quantitative genetics: Origins of genetic variation; Mendelian genetics; Hardy-Weinberg equilibrium; drift; selection (one-locus two-alleles model); population genetic structure (panmixia, gene flow, F_{ST}); polygenic traits; gene-environment interactions (phenotypic plasticity); heritability

Molecular evolution and phylogenetics: Neutral theory; molecular clocks; rates of evolution; phylogenetic reconstruction; molecular systematics

Macroevolution: Species concepts and speciation; adaptive radiation; convergence; biogeography

Section 3: Mathematics and Quantitative Ecology

Mathematics and statistics in ecology: Simple functions (linear, quadratic, exponential, logarithmic, etc); concept of derivatives and slope of a function; permutations and combinations; basic probability (probability of random events; sequences of events, etc); frequency distributions and their descriptive statistics (mean, variance, coefficient of variation, correlation, etc).

Statistical hypothesis testing: Concept of p-value; Type I and Type II error, test statistics like t-test and Chi-square test; basics of linear regression and ANOVA.

Section 4: Behavioural Ecology

Classical Ethology: Instinct; fixed action patters; imprinting; learnt behavior; proximate and ultimate questions

Sensory ecology: Neuroethology; communication (chemical, acoustic and visual signaling); recognition systems

Foraging ecology: Foraging behaviour; optimal foraging theory

Reproduction: Cost of sex; sexual dimorphism; mate choice; sexual selection (runaway selection, good-genes, handicap principle, etc); sexual conflict; mating systems; parental care.

Social living: Costs and benefits of group-living (including responses to predators); effect of competition (scramble and contest) on group formation; dominance relationships; eusociality; kin selection; altruism; reciprocity; human behaviour

Section 5: Applied Ecology & Evolution

Biodiversity and conservation: Importance of conserving biodiversity; ecosystem services; threats to biodiversity; invasive species; *in-situ* conservation (endemism, biodiversity hotspots, protected areas); *ex-situ* conservation; conservation genetics (genetic diversity, inbreeding depression); DNA fingerprinting and DNA barcoding

Disease ecology and evolution: Epidemiology; zoonotic diseases; antibiotic resistance; vector Control Plant and animal breeding: Marker assisted breeding; genetic basis of economically important traits

Global climate change: Causes; consequences; mitigation

GE Geomatics Engineering

PART A: Common

Engineering Mathematics - Surveying measurements, Accuracy, Precision, Most probable value, Errors and their adjustments, Regression analysis, Correlation coefficient, Lease square adjustment, Statistical significant value, Chi square test.

Remote Sensing - Basic concept, Electromagnetic spectrum, Spectral signature, Resolutions- Spectral. Spatial, Temporal and Radiometric, Platforms and Sensors, Remote Sensing Data Products - PAN, Multispectral, Microwave, Thermal, Hyperspectral, Visual and digital interpretation methods

GNSS - Principle used, Components of GNSS, Data collection methods, DGPS, Errors in observations and corrections.

GIS - Introduction, Data Sources, Data Models and Data Structures, Algorithms, DBMS, Creation of Databases (spatial and non-spatial), Spatial analysis - Interpolation, Buffer, Overlay, Terrain Modeling and Network analysis.

PART B: Section I

Maps - Importance of maps to engineering projects, Types of maps, Scales and uses, Plotting accuracy, Map sheet numbering, Coordinate systems- Cartesian and geographical, map projections, map datum – MSL, Geoid, spheroid, WGS-84.

Land Surveying - Various Levels, Levelling methods, Compass, Theodolite and Total Station and their uses, Tachometer, Trigonometric levelling, Traversing, Triangulation and Trilateration.

Aerial Photogrammetry - Types of photographs, Flying height and scale, Relief (height) displacement, Stereoscopy, 3-D Model, Height determination using Parallax Bar, Digital Elevation Model (DEM), Slope.

PART B: Section II

Data Quantization and Processing - Sampling and quantization theory, Principle of Linear System, Convolution, Continuous and Discrete Fourier Transform.

Digital Image Processing - Digital image characteristics: image histogram and scattergram and their significance, Variance-Covariance matrix, Correlation matrix and their significance.

Radiometric and Geometric Corrections – Registration and Resampling techniques.

Image Enhancement – Contrast Enhancement: Linear and Non-linear methods; Spatial Enhancement: Noise and Spatial filters

Image Transformation – Principal Component Analysis (PCA), Discriminant Analysis, Color transformations (RGB - IHS, CMYK), Indices (Ratios, NDVI, NDWI).

Image Segmentation and Classification – Simple techniques.

GG Geology and Geophysics

Part A : Common Section

Earth and planetary system – terrestrial planets and moons of the solar system; size, shape, internal structure and composition of the earth; concept of isostasy; elements of seismology – body and surface waves, propagation of body waves in the earth's interior; Heat flow within the earth; Gravitational field of the Earth; geomagnetism and paleomagnetism; continental drift; plate tectonics – relationship with earthquakes, volcanism and mountain building; continental and oceanic crust – composition, structure and thickness.

Weathering and soil formation; landforms created by river, wind, glacier, ocean and volcanoes.

Basic structural geology - stress, strain and material response; brittle and ductile deformation; nomenclature and classification of folds and faults.

Crystallography – basic crystal symmetry and concept of point groups. Mineralogy – silicate crystal structure and determinative mineralogy of common rock forming minerals.

Petrology of common igneous, sedimentary and metamorphic rocks.

Geological time scale; Geochronology and absolute time. Stratigraphic principles; major stratigraphic divisions of India.

Mineral, coal and petroleum resources of India.

Introduction to remote sensing.

Engineering properties of rocks and soils.

Elements of hydrogeology.

Principles and applications of gravity, magnetic, electrical, electromagnetic, seismic and radiometric methods of prospecting for oil, mineral and ground water; introductory well logging.

Part B (Section-1): Geology

Geomorphology - Geomorphic processes and agents; development and evolution of landforms in continental and oceanic settings; tectonic geomorphology.

Structural geology – Forces and mechanism of rock deformation; primary and secondary structures; geometry and genesis of planar and linear structures (bedding, cleavage, schistosity, lineation); folds, faults, joints and unconformities; Stereographic projection; shear zones, thrusts and superposed folding; basement-cover relationship. Interpretation of geological maps.

Crystallography and mineralogy- Elements of crystal symmetry, form and twinning; crystallographic projection; crystal chemistry; classification of minerals, physical and optical properties of rock-forming minerals.

Geochemistry – Cosmic abundance of elements; meteorites; geochemical evolution of the earth; geochemical cycles; distribution of major, minor and trace elements in crust and mantle; elements of high temperature and low temperature geochemical thermodynamics; isotopic evolution of the crust and the mantle, mantle reservoirs; geochemistry of water and water-rock interaction.

Igneous petrology – Classification, forms, textures and genesis of common igneous rocks; magmatic differentiation; binary and ternary phase diagrams; major and trace elements as monitors of partial melting and magma evolutionary processes. Mantle plumes, hotspots and large igneous provinces.

Sedimentology– Texture, structure and sedimentary processes; petrology of common sedimentary rocks; Sedimentary facies and environments, cyclicities in sedimentary succession; provencance and basin analysis. Important sedimentary basins of India.

Metamorphic petrology – Structures and textures of metamorphic rocks. Physico-chemical conditions of metamorphism and concept of metamorphic facies, grade and baric types; chemographic projections; metamorphism of pelitic, mafic and impure carbonate rocks; role of bulk composition including fluids in metamorphism; thermobarometry and metamorphic P-T-t paths, and their tectonic significance.

Paleobiology - Diversity of life through time, mass extinctions- causes and effects; taphonomy - processes of fossilization. Taxonomy. Morphology and functional morphology of invertebrates (bivalves, brachiopods, gastropods, echinoids, ammonites); microfossils (foraminifera, ostracoda, conodonts, bryozoa); Vertebrate paleonology (Equus, Probicidea, Human); Paleobotany (plant, spores, pollens). Basic concepts of ecology/paleoecology; classification - ecological and taxonomic schemes (diversity and richness). Fossils and paleoenvironments.

Stratigraphy – Principles of stratigraphy and concepts of correlation; Lithostratigraphy, biostratigraphy and chronostratigraphy. Principles of sequence stratigraphy and applications. Stratigraphy of peninsular and extra-peninsular India. Boundary problems in Indian stratigraphy.

Resource geology - Ore-mineralogy; ore forming processes vis-à-vis ore-rock association (magmatic, hydrothermal, sedimentary, supergene and metamorphogenic ores); fluid inclusions as ore genetic tools. Coal and petroleum geology; marine mineral resources. Prospecting and exploration of economic mineral deposits - sampling, ore reserve estimation, geostatistics, mining methods. Ore dressing and mineral economics. Distribution of mineral, fossil and nuclear fuel deposits in India.

Global tectonics – Plate motions, driving mechanisms, plate boundaries, supercontinent cycles.

Applied geology – Physico-mechanical properties of rocks and soils; rock index tests; Rock failure criteria (Mohr-Coulomb, Griffith and Hoek-Brown criteria); shear strength of rock discontinuities; rock mass classifications (RMR and Q Systems); in-situ stresses; rocks as construction materials; geological factors in the construction of engineering structures including dams, tunnels and excavation sites. Analysis of slope stability.

Natural hazards (landslide, volcanic, seismogenic, coastal) and mitigation. Principles of climate change.

Hydrogeology – Groundwater flow and exploration, well hydraulics and water quality.

Basic principles of remote sensing – energy sources and radiation principles, atmospheric absorption, interaction of energy with earth's surface, aerial-photo interpretation, multispectral

remote sensing in visible, infrared, thermal IR and microwave regions, digital processing of satellite images. GIS – basic concepts, raster and vector mode operations.

Part B (Section-2): Geophysics

Soild-Earth Geophysics - The earth as a planet; different motions of the earth; gravity field of the earth, Clairaut's theorem, size and shape of earth; geomagnetic field, paleomagnetism; Geothermics and heat flow; seismology and interior of the earth; variation of density, velocity, pressure, temperature, electrical and magnetic properties of the earth.

Geodesy - Gravitational Field of the Earth; Geoid; Ellipsoid; Geodetic Reference Systems; Datum; Everest (1830) and WGS 84 (1984) systems; GPS and DGPS; Levelling and Surveying.

Earthquake Seismology - Elements of elasticity theory- stress and strain tensors, Generalized Hooke's Law; Body and Surface Waves; Rotational, dilatational, irrorational and equivolumnal waves. Reflection and refraction of elastic waves; Inhomogenous and evanescent waves and bounded waves; Eikonal Equation and Ray theory; earthquakes-causes and measurements, magnitude and intensity, focal mechanisms; earthquake quantification, source characteristics, seismotectonics and seismic hazards; digital seismographs, Earthquake statistics, wave propogation in elastic media, quantifying earthquake source from seismological data. Elements of Seismic Tomography.

Potential and Time Varying Fields - Scalar and vector potential fields; Laplace, Maxwell and Helmholtz equations for solution of different types of boundary value problems in Cartesian, cylindrical and spherical polar coordinates; Green's theorem; Image theory; integral equations in potential and time-varying field theory.

Gravity Methods - Absolute and relative gravity measurements; Gravimeters; Land, airborne, shipborne and bore-hole gravity surveys; Tensorial Gravity sensors and surveys; various corrections for gravity data reduction – free air, Bouguer and isostatic anomalies; density estimates of rocks; regional and residual gravity separation; principle of equivalent stratum; data enhancement techniques, upward and downward continuation; derivative maps, wavelength filtering; preparation and analysis of gravity maps; gravity anomalies and their interpretation – anomalies due to geometrical and irregular shaped bodies, depth rules, calculation of mass.

Magnetic Methods - Elements of Earth's magnetic field, units of measurement, magnetic susceptibility of rocks and measurements, magnetometers and magnetic gradiometers, Land, airborne and marine magnetic and magnetic gradiometer surveys, Various corrections applied to magnetic data, IGRF, Reduction to Pole transformation, Poisson's relation of gravity and magnetic potential field, preparation of magnetic maps, upward and downward continuation, magnetic anomalies due to geometrical and irregular shaped bodies; Image processing concepts in processing of magnetic anomaly maps; Depth rules; Interpretation of processed magnetic anomaly data; derivative, analytic signal and Euler Depth Solutions. Applications of gravity and magnetic methods for mineral and oil exploration.

Electrical Methods - Conduction of electricity through rocks, electrical conductivities of metals, non-metals, rock forming minerals and different rocks, concepts of D.C. resistivity measurement and depth of investigation; Apparent Resistivity and Apparent Chargeability, Concept of Negative Apparent Resistivity and Negative Apparent Chargeability; Theory of Reciprocity, Sounding and Profiling, Various electrode arrangements, application of linear filter theory, Sounding curves over multi-layered earth, Dar-Zarrouk parameters, reduction of layers, Triangle of anisotropy,

interpretation of resistivity field data, Principles of equivalence and suppression, self-potential method and its origin; Electrical Resitivity Tomography (ERT); Induced polarization, time and frequency domain IP measurements; interpretation and applications of SP, resistivity and IP data sets for ground-water exploration, mineral exploration, environmental and engineering applications.

Electromagnetic Methods - Geo-electromagnetic spectrum; Biot Savart's Law; Maxwell's Equation, Helmotz Equation, Basic concept of EM induction in the earth, Skin-depth, elliptic polarization, in-phase and quadrature components, phasor diagrams; Response function and response parameters; Ground and Airborne Methods, measurements in different source-receiver configurations; Earth's natural electromagnetic methods-tellurics, geomagnetic depth sounding and magnetotellurics; Electromagnetic profiling and Sounding, Time domain EM method; EM scale modeling, processing of EM data and interpretation; Ground Penetrating Radar (GPR) Methods; Effect of conducting overburden;Geological applications including groundwater, mineral environmental and hydrocarbon exploration.

Seismic methods - Elastic properties of earth materials; Reflection, refraction and CDP surveys; land and marine seismic sources, generation and propagation of elastic waves, velocity – depth models, geophones, hydrophones, digital recording systems, digital formats, field layouts, seismic noise and noise profile analysis, optimum geophone grouping, noise cancellation by shot and geophone arrays, 2D, 3D and 4D seismic data acquisition, processing and interpretation; CDP stacking charts, binning, filtering, static and dynamic corrections, Digital seismic data processing, seismic deconvolution and migration methods, attribute analysis, bright and dim spots, seismic stratigraphy, high resolution seismics, VSP, AVO, multi-component seismics and seismic interferometry. Reservoir geophysics- Rock Physics and Petrophysics.

Geophysical Survey Design.

Geophysical signal processing - sampling theorem, Nyquist frequency, aliasing, Fourier series, periodic waveform, Fourier and Hilbert transform, Z-transform and wavelet transform; power spectrum, delta function, auto correlation, cross correlation, convolution, deconvolution, principles of digital filters, windows, poles and zeros.

Geophysical Well Logging - Principles and techniques of geophysical well-logging, SP, resistivity, induction, gamma ray, neutron, density, sonic, temperature, dip meter, caliper, nuclear magnetic resonance- longitudinal and transverse relaxation, CPMG sequence, porosity characterization, cement bond logging, micro-logs. Pulsed Neutron Devices and Spectroscopy Multi-Array and Triaxial Induction Devices; Quantitative evaluation of formations from well logs; Logging while drilling; High angle and horizontal wells; Clay Quantification; Lithology and Porosity Estimation; Saturation and Permeability Estimation; application of bore hole geophysics in ground water, mineral and oil exploration.

Radioactive Methods - Prospecting and assaying of mineral (radioactive and non-radioactive) deposits, half-life, decay constant, radioactive equilibrium, G M counter, scintillation detector, semiconductor devices, application of radiometric for exploration, assaying and radioactive waste disposal.

Geophysical Inversion - Basic concepts of forward and inverse problems, Ill-posedness of inverse problems, condition number, non-uniqueness and stability of solutions; L1, L2 and Lp norms, overdetermined, underdetermined and mixed determined inverse problems, quasi-linear and non-linear methods including Tikhonov's regularization method, Singular Value Decomposition, Backus-Gilbert method, simulated annealing, genetic algorithms, swarm intelligence, machine learning and

artificial neural networks. Statistics of misfit and likelihood, Bayesian construction of posterior probabilities, sparsity promoting L1 optimization. Ambiguity and uncertainty in geophysical interpretation.

IN Instrumentation Engineering

Section 1: Engineering Mathematics

Linear Algebra: Matrix algebra, systems of linear equations, consistency and rank, Eigen value and Eigen vectors.

Calculus: Mean value theorems, theorems of integral calculus, partial derivatives, maxima and minima, multiple integrals, Fourier series, vector identities, line, surface and volume integrals, Stokes, Gauss and Green's theorems.

Differential equations: First order equation (linear and nonlinear), second order linear differential equations with constant coefficients, method of variation of parameters, Cauchy's and Euler's equations, initial and boundary value problems, solution of partial differential equations: variable separable method.

Analysis of complex variables: Analytic functions, Cauchy's integral theorem and integral formula, Taylor's and Laurent's series, residue theorem, solution of integrals.

Probability and Statistics: Sampling theorems, conditional probability, mean, median, mode, standard deviation and variance; random variables: discrete and continuous distributions: normal, Poisson and binomial distributions.

Numerical Methods: Matrix inversion, solutions of non-linear algebraic equations, iterative methods for solving differential equations, numerical integration, regression and correlation

analysis.

Section 2: Electricity and Magnetism

Coulomb's Law, Electric Field Intensity, Electric Flux Density, Gauss's Law, Divergence, Electric field and potential due to point, line, plane and spherical charge distributions, Effect of dielectric medium, Capacitance of simple configurations, Biot-Savart's law, Ampere's law, Curl, Faraday's law, Lorentz force, Inductance, Magnetomotive force, Reluctance, Magnetic circuits, Self and Mutual inductance of simple configurations.

Section 3: Electrical Circuits and Machines

Voltage and current sources: independent, dependent, ideal and practical; v-i relationships of resistor, inductor, mutual inductance and capacitor; transient analysis of RLC circuits with dc excitation.

Kirchoff's laws, mesh and nodal analysis, superposition, Thevenin, Norton, maximum power transfer and reciprocity theorems.

Peak-, average- and rms values of ac quantities; apparent-, active- and reactive powers; phasor analysis, impedance and admittance; series and parallel resonance, locus diagrams, realization of basic filters with R, L and C elements. transient analysis of RLC circuits with ac excitation.

One-port and two-port networks, driving point impedance and admittance, open-, and short circuit parameters.

Single phase transformer: equivalent circuit, phasor diagram, open circuit and short circuit tests, regulation and efficiency; Three phase induction motors: principle of operation, types, performance, torque-speed characteristics, no-load and blocked rotor tests, equivalent circuit, starting and speed control; Types of losses and efficiency calculations of electric machines.

Section 4: Signals and Systems

Periodic, aperiodic and impulse signals; Laplace, Fourier and z-transforms; transfer function, frequency response of first and second order linear time invariant systems, impulse response of systems; convolution, correlation. Discrete time system: impulse response, frequency response, pulse transfer function; DFT and FFT; basics of IIR and FIR filters.

Section 5: Control Systems

Feedback principles, signal flow graphs, transient response, steady-state-errors, Bode plot, phase and gain margins, Routh and Nyquist criteria, root loci, design of lead, lag and lead-lag

compensators, state-space representation of systems; time-delay systems; mechanical, hydraulic and pneumatic system components, synchro pair, servo and stepper motors, servo valves; on-off, P, PI, PID, cascade, feedforward, and ratio controllers, tuning of PID controllers and sizing of control valves.

Section 6: Analog Electronics

Characteristics and applications of diode, Zener diode, BJT and MOSFET; small signal analysis of transistor circuits, feedback amplifiers. Characteristics of ideal and practical operational amplifiers; applications of opamps: adder, subtractor, integrator, differentiator, difference amplifier, instrumentation amplifier, precision rectifier, active filters, oscillators, signal generators, voltage controlled oscillators and phase locked loop, sources and effects of noise and interference in electronic circuits.

Section 7: Digital Electronics

Combinational logic circuits, minimization of Boolean functions. IC families: TTL and CMOS. Arithmetic circuits, comparators, Schmitt trigger, multi-vibrators, sequential circuits, flipflops, shift registers, timers and counters; sample-and-hold circuit, multiplexer, analog-to-digital (successive approximation, integrating, flash and sigma-delta) and digital-to-analog converters (weighted R, R-

2R ladder and current steering logic). Characteristics of ADC and DAC (resolution, quantization, significant bits, conversion/settling time); basics of number systems, Embedded Systems: Microprocessor and microcontroller applications, memory and input-output interfacing; basics of data acquisition systems, basics of distributed control systems (DCS) and programmable logic controllers (PLC).

Section 8: Measurements

SI units, standards (R,L,C, voltage, current and frequency), systematic and random errors in measurement, expression of uncertainty - accuracy and precision, propagation of errors, linear and weighted regression. Bridges: Wheatstone, Kelvin, Megohm, Maxwell, Anderson, Schering and Wien for measurement of R, L, C and frequency, Q-meter. Measurement of voltage, current and power in single and three phase circuits; ac and dc current probes; true rms meters, voltage and current scaling, instrument transformers, timer/counter, time, phase and frequency measurements, digital voltmeter, digital multimeter; oscilloscope, shielding and grounding.

Section 9: Sensors and Industrial Instrumentation

Resistive-, capacitive-, inductive-, piezoelectric-, Hall effect sensors and associated signal conditioning circuits; transducers for industrial instrumentation: displacement (linear and angular), velocity, acceleration, force, torque, vibration, shock, pressure (including low pressure), flow (variable head, variable area, electromagnetic, ultrasonic, turbine and open channel flow meters) temperature (thermocouple, bolometer, RTD (3/4 wire), thermistor, pyrometer and semiconductor); liquid level, pH, conductivity and viscosity measurement. 4-20 mA two-wire transmitter.

Section 10: Communication and Optical Instrumentation

Amplitude- and frequency modulation and demodulation; Shannon's sampling theorem, pulse code modulation; frequency and time division multiplexing, amplitude-, phase-, frequency-, quadrature amplitude, pulse shift keying for digital modulation; optical sources and detectors: LED, laser, photo-diode, light dependent resistor, square law detectors and their characteristics; interferometer: applications in metrology; basics of fiber optic sensing. UV-VIS Spectro photometers, Mass spectrometer.

MA	Mathematics

Calculus: Functions of two or more variables, continuity, directional derivatives, partial derivatives, total derivative, maxima and minima, saddle point, method of Lagrange's multipliers; Double and Triple integrals and their applications to area, volume and surface area; Vector Calculus: gradient, divergence and curl, Line integrals and Surface integrals, Green's theorem, Stokes' theorem, and Gauss divergence theorem.

Linear Algebra: Finite dimensional vector spaces over real or complex fields; Linear transformations and their matrix representations, rank and nullity; systems of linear equations, characteristic polynomial, eigenvalues and eigenvectors, diagonalization, minimal polynomial, Cayley-Hamilton Theorem, Finite dimensional inner product spaces, Gram-Schmidt orthonormalization process, symmetric, skew-symmetric, Hermitian, skew-Hermitian, normal, orthogonal and unitary matrices; diagonalization by a unitary matrix, Jordan canonical form; bilinear and quadratic forms.

Real Analysis: Metric spaces, connectedness, compactness, completeness; Sequences and series of functions, uniform convergence, Ascoli-Arzela theorem; Weierstrass approximation theorem; contraction mapping principle, Power series; Differentiation of functions of several variables, Inverse and Implicit function theorems; Lebesgue measure on the real line, measurable functions; Lebesgue integral, Fatou's lemma, monotone convergence theorem, dominated convergence theorem.

Complex Analysis: Functions of a complex variable: continuity, differentiability, analytic functions, harmonic functions; Complex integration: Cauchy's integral theorem and formula; Liouville's theorem, maximum modulus principle, Morera's theorem; zeros and singularities; Power series, radius of convergence, Taylor's series and Laurent's series; Residue theorem and applications for evaluating real integrals; Rouche's theorem, Argument principle, Schwarz lemma; Conformal mappings, Mobius transformations.

Ordinary Differential equations: First order ordinary differential equations, existence and uniqueness theorems for initial value problems, linear ordinary differential equations of higher order with constant coefficients; Second order linear ordinary differential equations with variable coefficients; Cauchy-Euler equation, method of Laplace transforms for solving ordinary differential equations, series solutions (power series, Frobenius method); Legendre and Bessel functions and their orthogonal properties; Systems of linear first order ordinary differential equations, Sturm's oscillation and separation theorems, Sturm-Liouville eigenvalue problems, Planar autonomous systems of ordinary differential equations: Stability of stationary points for linear systems with constant coefficients, Linearized stability, Lyapunov functions.

Algebra: Groups, subgroups, normal subgroups, quotient groups, homomorphisms, automorphisms; cyclic groups, permutation groups, Group action, Sylow's theorems and their applications; Rings, ideals, prime and maximal ideals, quotient rings, unique factorization domains, Principle ideal domains, Euclidean domains, polynomial rings, Eisenstein's irreducibility criterion; Fields, finite fields, field extensions, algebraic extensions, algebraically closed fields

Functional Analysis: Normed linear spaces, Banach spaces, Hahn-Banach theorem, open mapping and closed graph theorems, principle of uniform boundedness; Inner-product spaces, Hilbert spaces,

orthonormal bases, projection theorem, Riesz representation theorem, spectral theorem for compact self-adjoint operators.

Numerical Analysis: Systems of linear equations: Direct methods (Gaussian elimination, LU decomposition, Cholesky factorization), Iterative methods (Gauss-Seidel and Jacobi) and their convergence for diagonally dominant coefficient matrices; Numerical solutions of nonlinear equations: bisection method, secant method, Newton-Raphson method, fixed point iteration; Interpolation: Lagrange and Newton forms of interpolating polynomial, Error in polynomial interpolation of a function; Numerical differentiation and error, Numerical integration: Trapezoidal and Simpson rules, Newton-Cotes integration formulas, composite rules, mathematical errors involved in numerical integration formulae; Numerical solution of initial value problems for ordinary differential equations: Methods of Euler, Runge-Kutta method of order 2.

Partial Differential Equations: Method of characteristics for first order linear and quasilinear partial differential equations; Second order partial differential equations in two independent variables: classification and canonical forms, method of separation of variables for Laplace equation in Cartesian and polar coordinates, heat and wave equations in one space variable; Wave equation: Cauchy problem and d'Alembert formula, domains of dependence and influence, non-homogeneous wave equation; Heat equation: Cauchy problem; Laplace and Fourier transform methods.

Topology: Basic concepts of topology, bases, subbases, subspace topology, order topology, product topology, quotient topology, metric topology, connectedness, compactness, countability and separation axioms, Urysohn's Lemma.

Linear Programming: Linear programming models, convex sets, extreme points; Basic feasible solution, graphical method, simplex method, two phase methods, revised simplex method ; Infeasible and unbounded linear programming models, alternate optima; Duality theory, weak duality and strong duality; Balanced and unbalanced transportation problems, Initial basic feasible solution of balanced transportation problems (least cost method, north-west corner rule, Vogel's approximation method); Optimal solution, modified distribution method; Solving assignment problems, Hungarian method.

ME	Mechanical Engineering

Section 1: Engineering Mathematics

Linear Algebra: Matrix algebra, systems of linear equations, eigenvalues and eigenvectors.

Calculus: Functions of single variable, limit, continuity and differentiability, mean value theorems, indeterminate forms; evaluation of definite and improper integrals; double and triple integrals; partial derivatives, total derivative, Taylor series (in one and two variables), maxima and minima, Fourier series; gradient, divergence and curl, vector identities, directional derivatives, line, surface and volume integrals, applications of Gauss, Stokes and Green's theorems.

Differential equations: First order equations (linear and nonlinear); higher order linear differential equations with constant coefficients; Euler-Cauchy equation; initial and boundary value problems; Laplace transforms; solutions of heat, wave and Laplace's equations.

Complex variables: Analytic functions; Cauchy-Riemann equations; Cauchy's integral theorem and integral formula; Taylor and Laurent series.

Probability and Statistics: Definitions of probability, sampling theorems, conditional probability; mean, median, mode and standard deviation; random variables, binomial, Poisson and normal distributions.

Numerical Methods: Numerical solutions of linear and non-linear algebraic equations; integration by trapezoidal and Simpson's rules; single and multi-step methods for differential equations.

Section 2: Applied Mechanics and Design

Engineering Mechanics: Free-body diagrams and equilibrium; friction and its applications including rolling friction, belt-pulley, brakes, clutches, screw jack, wedge, vehicles, etc.; trusses and frames; virtual work; kinematics and dynamics of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations; Lagrange's equation.

Mechanics of Materials: Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; thin cylinders; shear force and bending moment diagrams; bending and shear stresses; concept of shear centre; deflection of beams; torsion of circular shafts; Euler's theory of columns; energy methods; thermal stresses; strain gauges and rosettes; testing of materials with universal testing machine; testing of hardness and impact strength.

Theory of Machines: Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of linkages; cams; gears and gear trains; flywheels and governors; balancing of reciprocating and rotating masses; gyroscope.

Vibrations: Free and forced vibration of single degree of freedom systems, effect of damping; vibration isolation; resonance; critical speeds of shafts.

Machine Design: Design for static and dynamic loading; failure theories; fatigue strength and the S-N diagram; principles of the design of machine elements such as bolted, riveted and welded joints; shafts, gears, rolling and sliding contact bearings, brakes and clutches, springs.

Section 3: Fluid Mechanics and Thermal Sciences

Fluid Mechanics: Fluid properties; fluid statics, forces on submerged bodies, stability of floating bodies; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; dimensional analysis; viscous flow of incompressible fluids, boundary layer, elementary turbulent flow, flow through pipes, head losses in pipes, bends and fittings; basics of compressible fluid flow.

Heat-Transfer: Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system, Heisler's charts; thermal boundary layer, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes, effect of turbulence; heat exchanger performance, LMTD and NTU methods; radiative heat transfer, Stefan-Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis

Thermodynamics: Thermodynamic systems and processes; properties of pure substances, behavior of ideal and real gases; zeroth and first laws of thermodynamics, calculation of work and heat in various processes; second law of thermodynamics; thermodynamic property charts and tables, availability and irreversibility; thermodynamic relations.

Applications: *Power Engineering*: Air and gas compressors; vapour and gas power cycles, concepts of regeneration and reheat. *I.C. Engines*: Air-standard Otto, Diesel and dual cycles. *Refrigeration and air-conditioning*: Vapour and gas refrigeration and heat pump cycles; properties of moist air, psychrometric chart, basic psychrometric processes. *Turbomachinery*: Impulse and reaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbines; steam and gas turbines.

Section 4: Materials, Manufacturing and Industrial Engineering

Engineering Materials: Structure and properties of engineering materials, phase diagrams, heat treatment, stress-strain diagrams for engineering materials.

Casting, Forming and Joining Processes: Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding.

Machining and Machine Tool Operations: Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining; principles of non-traditional machining processes; principles of work holding, jigs and fixtures; abrasive machining processes; NC/CNC machines and CNC programming.

Metrology and Inspection: Limits, fits and tolerances; linear and angular measurements; comparators; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly; concepts of coordinate-measuring machine (CMM).

Computer Integrated Manufacturing: Basic concepts of CAD/CAM and their integration tools; additive manufacturing.

Production Planning and Control: Forecasting models, aggregate production planning, scheduling, materials requirement planning; lean manufacturing.

Inventory Control: Deterministic models; safety stock inventory control systems.

Operations Research: Linear programming, simplex method, transportation, assignment, network flow models, simple queuing models, PERT and CPM.

MN	Mining Engineering

Section 1: Engineering Mathematics:

Linear Algebra: Matrices and Determinants; Inverse and Rank of matrix; Systems of linear equations; Eigen values and Eigen vectors. Cayley-Hamilton Theorem.

Calculus: Limit, continuity and differentiability; Partial Derivatives; Mean value theorems; Indeterminate forms and L' Hospital's rule; Maxima and minima; Taylor's theorem; Sequences and series; Test for convergence; Fourier series.

Vector Calculus: Gradient; Divergence and Curl; Line; surface and volume integrals; Stokes, Gauss and Green's theorems.

Differential Equations: Linear and non-linear first order ODEs; Higher order linear ODEs with constant coefficients; Cauchy's and Euler's equations.

Probability and Statistics: Measures of central tendency and dispersion; hypothesis testing; Binomial, Poisson, exponential and normal distributions; Correlation and regression analysis.

Numerical Methods: Solutions of linear algebraic equations; Interpolation; Integration of trapezoidal and Simpson's rule; Single and multi-step methods for differential equations.

Section 2: Mining Geology, Mine Development and Surveying:

Mining Geology: Minerals, Rocks and their Origin, Classification, Ore Genesis; Structural Geology.

Mine Development: Methods of access to deposits; Underground drivages; Drilling method and machines; Explosives and energetics, blasting devices, blast design practices; Rock-Tool Interaction applicable to mechanical cutting systems and their selection.

Mine Surveying: Levels and levelling, theodolite, tacheometry, triangulation; Contouring; Errors and adjustments; Correlation; Underground surveying; Curves; Photogrammetry; EDM, Total Station, GPS, Basics of GIS and remote sensing.

Section 3: Geomechanics and Ground Control:

Engineering Mechanics: Equivalent force systems; Equations of equilibrium; Two dimensional frames and trusses; Free body diagrams; Friction forces; Particle kinematics and dynamics; Beam analysis.

Geomechanics: Geo-technical properties of rocks; Rock mass classification; Instrumentation and in-situ stress measurement techniques; Theories of rock failure; Ground vibrations; Stress distribution around mine openings; Subsidence; Slope stability.

Ground Control: Design of pillars; Roof supporting systems; Mine filling. Strata Control and Monitoring Plan.

Section 4: Mining Methods and Machinery:

Mining Methods: Surface mining: layout, development, loading, transportation and mechanization, continuous surface mining systems; highwall mining; Underground coal mining: bord and pillar systems, room and pillar mining, longwall mining, thick seam mining methods, Underground metal mining: open, supported and caved stoping methods, stope mechanization, ore handling systems.

Mining Machinery: Generation and transmission of mechanical, hydraulic and pneumatic power; Materials handling: wire ropes, haulages, conveyors, face and development machinery, hoisting systems, pumps; comminution methods and machinery.

Section 5: Surface Environment, Mine Ventilation and Underground Hazards:

Surface Environment: Air, water and soil pollution: Standards of quality, causes and dispersion of contamination and control; Noise pollution and control; Land reclamation; EIA.

Mine Ventilation: Underground atmosphere; Heat load sources and thermal environment, air cooling; Mechanics of airflow, distribution, natural and mechanical ventilation; Mine fans and usage; Auxiliary ventilation; Ventilation survey and planning; Ventilation networks.

Underground Hazards: Mine Gases, Methane drainage; Underground hazards from fires, explosions, dust and inundation; Rescue apparatus and practices; Safety management plan; Accident data analysis; assessment; Mine lighting; Mine legislation; Occupational health and safety.

Section 6: Mineral Economics, Mine Planning, Systems Engineering:

Mineral Economics: Mineral resource classification; Discounted cash flow analysis; Mine valuation; Mineral taxation.

Mine Planning: Sampling methods, practices and interpretation; Reserve estimation techniques: Basics of geostatistics and quality control; Optimization of facility location; Mine planning and its components, Determination of mine size and mine life; Ultimate pit configuration and its determination, Optimum mill cut-off grade and its determination, Stope planning, Design of haul road, Selection of mining system vis-à-vis equipment system.

Systems Engineering: Concepts of reliability; Reliability of simple systems; Maintainability and availability; Linear programming, transportation and assignment problems; Network analysis; Inventory models; Queuing theory; Decision trees.

MT	Metallurgical Engineering

Section 1: Engineering Mathematics

Linear Algebra: Matrices and Determinants, Systems of linear equations, Eigen values and Eigen vectors.

Calculus: Limit, Continuity and Differentiability; Partial derivatives; Maxima and minima; Sequences and series; Test for convergence; Fourier series.

Vector Calculus: Gradient; Divergence and Curl; Line, Surface and volume integrals; Stokes, Gauss and Green's theorems.

Differential Equations: Linear and non-linear first order ODEs; Higher order linear ODEs with constant coefficients; Cauchy's and Euler's equations; Laplace transforms; PDEs –Laplace, one dimensional heat and wave equations.

Probability and Statistics: Definitions of probability and sampling theorems, conditional probability, Mean, median, mode and standard deviation; Random variables; Poisson, normal and binomial distributions; Analysis of experimental data; linear least squares method.

Numerical Methods: Solutions of linear and non-linear (Bisection, Secant, Newton- Raphson methods) algebraic equations; integration by trapezoidal and Simpson's rule; single and multi-step methods for differential equations.

Section 2: Metallurgical Thermodynamics

Laws of thermodynamics: First law – energy conservation, Second law - entropy; Enthalpy, Gibbs and Helmholtz free energy; Maxwell's relations; Chemical potential; Applications to metallurgical systems, solutions, ideal and regular solutions; Gibbs phase rule, phase equilibria, binary phase diagram and lever rule, free-energy vs. composition diagrams; Equilibrium constant, Activity, Ellingham and phase stability diagrams; Thermodynamics of point defects, surfaces and interfaces, adsorption and segregation phenomena.

Electrochemistry: Single electrode potential, Electrochemical cells, Nernst equation, Potential-pH diagrams.

Section 3: Transport Phenomena and Rate Processes

Momentum transfer: Concept of viscosity, shell balances, Bernoulli's equation, mechanical energy balance equation, flow past plane surfaces and through pipes.

Heat transfer: Conduction, Fourier's Law, 1-D steady state conduction.

Convection: Heat transfer coefficient relations for forced convection.

Radiation: Black body radiation, Stefan-Boltzman Law, Kirchhoff's Law.

Mass transfer: Diffusion and Fick's laws, Mass transfer coefficients.

Dimensional analysis: Buckingham Pi theorem, Significance of dimensionless numbers.

Basic laws of chemical kinetics: First order reactions, reaction rate constant, Arrhenius relation, heterogeneous reactions, oxidation kinetics.

Electrochemical kinetics: Polarization.

Section 4: Mineral Processing and Extractive Metallurgy

Comminution techniques, Size classification, Flotation, Gravity and other methods of mineral beneficiation; Agglomeration: sintering, pelletizing and briquetting.

Material and Energy balances in metallurgical processes; Principles and processes for the extraction of non-ferrous metals – aluminum, copper and titanium.

Iron and steel making: Material and heat balance in blast furnace; Structure and properties of slags and molten salts – basicity of slags - sulphide and phosphate capacity of slags; Production of metallurgical coke.

Other methods of iron making (COREX, MIDRE)

Primary steel making: Basic oxygen furnace, process dynamics, oxidation reactions, electric arc furnace.

Secondary steel making: Ladle process – deoxidation, argon stirring, desulphurization, inclusion shape control, principles of degassing methods; Basics of stainless steel manufacturing.

Continuous Casting: Fluid flow in the tundish and mould, heat transfer in the mould, segregation, inclusion control.

Section 5: Physical Metallurgy

Chemical Bonding: Ionic, covalent, metallic, and secondary bonding in materials, Crystal structure of solids – metals and alloys, ionic and covalent solids, and polymers.

X-ray Diffraction – Bragg's law, optical metallography, principles of SEM imaging.

Crystal Imperfections: Point, line and surface defects; Coherent, semi-coherent and incoherent interfaces.

Diffusion in solids: Diffusion equation, steady state and error function solutions; Examples-homogenenization and carburization; Kirkendall effect; Uphill diffusion; Atomic models for interstitial and substitutional diffusion; Pipe diffusion and grain boundary diffusion.

Phase transformation: Driving force, Homogeneous and heterogeneous nucleation, growth Kinetics Solidification in isomorphous, eutectic and peritectic systems, cast structures and macrosegregation, dendritic solidification and constitutional supercooling, coring and microsegregation.

Solid state transformations: Precipitation, spinoidal decomposition, ordering, massive transformation, discontinuous precipitation, eutectoid transformation, diffusionless transformations; Precipitate coarsening, Gibbs-Thomson effect.

Principles of heat treatment of steels, TTT and CCT diagrams; Surface hardening treatments; Recovery, recrystallization and grain growth; Heat treatment of cast iron and aluminium alloys.

Electronic, magnetic and optical properties of materials.

Basic forms of corrosion and its prevention

Section 6: Mechanical Metallurgy

Strain tensor and stress tensor, Representation by Mohr's circle, elasticity, stiffness and compliance tensor, Yield criteria, Plastic deformation by slip and twinning.

Dislocation theory: Edge, screw and mixed dislocations, source and multiplication of dislocations, stress fields around dislocations; Partial dislocations, dislocation interactions and reactions.

Strengthening mechanisms: Work/strain hardening, strengthening due to grain boundaries,

solid solution, precipitation and dispersion.

Fracture behaviour, Griffith theory, linear elastic fracture mechanics, fracture toughness, fractography, ductile to brittle transition.

Fatigue: Cyclic stress strain behaviour - low and high cycle fatigue, crack growth.

Mechanisms of high temperature deformation and failure; creep and stress rupture, stress exponent and activation energy.

Section 7: Manufacturing Processes

Metal casting: Mould design involving feeding, gating and risering, casting practices, casting defects.

Hot, warm and cold working of metals: Metal forming – fundamentals of metal forming processes of rolling, forging, extrusion, wire drawing and sheet metal forming, defects in forming.

Metal joining: Principles of soldering, brazing and welding, welding metallurgy, defects in welded joints in steels and aluminum alloys.

Powder metallurgy: production of powders, compaction and sintering.

Non-destructive Testing (NDT): Dye-penetrant, ultrasonic, radiography, eddy current, acoustic emission and magnetic particle inspection methods.

NM	Naval Architecture & Marine Engineering

Section 1: Engineering Mathematics

Determinants and matrices, Systems of linear equations, Eigenvalues and eigenvectors.

Functions, gradient, divergence, curl, chain rules, partial derivatives, directional derivatives, definite and indefinite integrals, line surface and volume integrals, theorems of Stokes, Gauss and Green.

Linear, non-linear, first and higher order ordinary and partial differential equations, separation of variables.

Laplace transformation, analytical functions of complex variables, Fourier series, numerical methods for differentiation and integration, complex analysis, probability and statistics.

Section 2: Applied Mechanics and Structures

Engineering Mechanics: Free-body diagrams and equilibrium; trusses and frames; virtual work; kinematics and dynamics of particles and rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations.

Mechanics of Materials: Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; shear force and bending moment diagrams; bending and shear stresses; torsion; Euler's theory of columns; energy methods; theories and failure, material testing methods.

Vibrations: Free and forced vibration of damped and undamped systems, single and multi DOF systems.

Machine Design: Design for static and dynamic loading; Design of machine elements such as shafts, gears, rolling and sliding contact bearings; Joining technics such as bolting, riveting and welding.

Section 3: Fluid Mechanics and Marine Hydrodynamics

Fluid Mechanics: Fluid properties; fluid statics, stability of floating bodies; Conservation laws: Mass, momentum and energy (Integral and differential form); Dimensional analysis and dynamic similarity; sources, sinks, doublets, line vortex and their superposition; Stoke's integral theorem. Generalised Bernoulli's equation, sources, sinks, dipole, Flow with circulation, potential flow with rotational symmetry, hydrodynamical lift, Kutta-Joukowski theorem. Vortex motion- Fundamental concepts, vortex analogy to Biot-Savart's law, straight parallel vortex filaments, vortex sheets. Viscous flow- Navier-Stokes equations, Couette flow, Plane poiseuille flow. Equation of continuity, Euler's equation, Bernoulli's equation, Viscous flow of incompressible fluids, elementary turbulent flow, boundary layer, flow through pipes.

Boundary layer theory- Prandtl's boundary layer equations, criterion for separation, Blasius solution, Skin friction, displacement thickness, momentum thickness, Turbulent boundary layer, Boundary layer control. Airfoils- Lift, drag, circulation, pressure distribution-theory of thin aerofoils, wings of infinite and finite span, circulation distribution, Cavitation.

Vorticity and Kelvin's theorem, Potential flow theory, Sources, Sinks and Doublets, hydrodynamic forces in potential flow, D'Alembert's paradox, added-mass, slender-body theory, hydrodynamic model testing, scaling laws, application of potential theory to surface waves, energy transport, wave/body forces, linearised theory of lifting surfaces.

Section 4: Naval Architecture and Ocean Engineering

Ship geometry and physical fundamentals - Archimedes' principle, buoyancy and weight of ship, laws of flotation, heel and trim, stable and unstable equilibrium of ships, importance of streamlined hull shape, ship main particulars, hydrostatic calculations,

Stability and trim of Ships: Statical stability at small angles of heel, Inclining experiment. Shift of centre of gravity due to addition or removal of mass, transverse movement of mass and effect, Free surface effect, Effect of suspended mass, Stability at large angles of heel, angle of loll, curves of statical stability, dynamical stability, Probabilistic and deterministic Damage Stability Different Characteristic curves of dynamic stability. Floodable length calculations and curves. Loss of stability due to grounding, docking stability.

Resistance & Propulsion: Components of ship resistance, form factor, hull roughness, model testing and ship resistance prediction methods, tank wall effects, determination of ship resistance different series test results, resistance of advanced vehicles, appendage and added resistance. Geometry of screw propeller, propeller theories, hull-propeller interactions, different propulsive efficiency definitions. Propeller cavitation and effects. Propeller design and series. Open water and self-propulsion model tests. Different types of propellers and their working principles. Propeller material, strength and manufacturing.Unconventional propellers

Ship Manoeuvring and Motions: Ship path keeping and changing, equations of motion, linearised equations and control fixed stability indexes, model tests. Stability and control in the horizontal and vertical planes – definitive manoeuvres and sea trials. Rudder hydrodynamics, design and operation. Influence of propeller, hull, appendages etc. on rudder performance. Experimental methods for the determination of hydrodynamic derivatives.

Ocean waves – regular, irregular, trochoidal. Wave spectrum, encounter frequency. Types of ship motions, coupled and non-coupled motions, equations of motion. Dynamic effects of ship motion in seaway. Different ship motion stabilisers – passive and active. Different numerical and experimental methods to determine ship motions – strip theory, BEM, FEM. Seakeeping features of high-performance marine vehicles.

Ship Structures & Strength: Shipbuilding materials, joining techniques, ship structural and framing systems – bottom, side, deck, bulkhead, end structures, and structural connections. Primary and secondary structural members, superstructure, hatch covers, machinery foundations, cargo handling systems and support structures.

Loads acting on ships in seaway, longitudinal and transverse strength considerations and estimation methods. Strength of hull girder, stiffened plate analysis, torsion of hull girder, deformation and stresses, local strength analysis; Reliability analysis and ultimate strength of hull girder, structural vibrations, fatigue and fracture.

Physical Oceanography: Physical properties of seawater, Different types of ocean waves - tides and wind waves, and their importance. Offshore Structures: Fixed offshore platforms - Jackets, Gravity platforms; Floating platforms - semi-submersibles, jack-ups, TLPs, FPSOs; Mooring, station keeping. Port and Harbour Engineering: Ports and Harbours, Port structures - Jetties, Dolphins, Liquid berths, Dredging, Navigation

Section 5: Thermodynamics and Marine Engineering

Thermodynamics: First law of thermodynamics - Closed system undergoing a cycle; closed system undergoing a change of state; Internal energy of a system; Expansion work; Process using ideal gas - constant pressure, constant volume, isothermal; adiabatic and polytropic process -work done and heat added in different process; First law applied to one - dimensional steady flow process, flow energy, steady flow energy equation (ID). Second law of Thermodynamics - Different statements; Reversible and irreversible process; Corollaries of second law - Absolute temperature scale; Carnot cycle - Carnot engine, refrigerator and heat pump. Clausius inequality and definition of entropy, change of entropy of an ideal gas; Gas power cycles and I.C.Engines; Gas power cycles: Carnot cycle, Brayton cycle, Erricson cycle, Sterling cycle etc.; Air standard cycles- Otto- Diesel, Dual and Joule cycle; Evaluation of thermal efficiency and mean effective pressure; Internal Combustion engine - Classification of I.C. engines -Principle of operation of spark Ignition and Compression Ignition engines both two stroke and four stroke; Stages of combustion in S.I. and C.I. engines;

Knocking and detonation-factors controlling knock and detonation, methods of preventing Knocking and detonation; Refrigeration - principle of operation of Simple vapour compression system, Comparison with vapour compression systems; Air conditioning principles - Sensible heating and cooling, Humidification and dehumidification, Cooling and humidification, Cooling and dehumidification- Heating and humidification, Heating and dehumidification, Adiabatic mixing of air streams –cooling and heating load calculation.

Marine Diesel Engines: General engine principles, Low speed and medium speed diesel engines, Two and Four stroke engines, Scavenging and turbocharging, Fuel oil system, Lubricating oil systems, cooling systems, torque and power measurement, Starting air systems and reversing systems, controls and safety devices, Couplings and Gearboxes, Specific Fuel Consumption. Waste heat recovery system, MARPOL regulations and Energy Efficiency Design Index (EEDI), Ship Energy Efficiency Management Plan (SEEMP).

Marine Steam Turbines: Types of turbines, compounding, reheat, turbine construction, rotors, blades, casing, Gland sealing, diaphragms, nozzles, bearings etc. Lubrication systems, expansion arrangements, Gearings. Marine gas turbines – fundamentals of G.T, Structure of gas turbines, gearing, operational features, controls, combined cycles. Nuclear propulsion –physical principles of the operation of nuclear reactors – use of nuclear propulsion on seagoing vessels, Electrical Propulsion,

Marine Boilers: Types - fire tube, water tube boilers, Package boilers, Cochran Boilers, Composite boilers, steam to steam generators, double evaporation boilers, exhaust gas heat exchangers, auxiliary steam plant systems, exhaust gas boilers, composite boilers. Boiler mounting, combustion, feed system, feedwater treatment.

Engine Dynamics: Torsional vibration of engine and shafting, axial shaft vibration, critical speeds, engine rating, rating corrections, trial tests etc. Relationship of engine to the propeller classification society rules on engine construction, Engine room arrangement. Automation of ship propulsion plants, Maintenance requirements and reliability of propulsion plants.

Marine Auxiliary Machinery & Systems: Different types of pumps and piping systems in ships - hot water, drinking water, cooling water and seawater, fuel oil systems, lubricating oil system filters, coolers, centrifuges, purifiers and clarifiers, bilge and ballast systems, sewage disposal, oily water separator, air compressors, boilers, heat exchangers, waste heat recovery systems; Heat, ventilation and air conditioning systems; Dech machinery and cargo handling systems; Propulsions and steering gear systems.

PE Petroleum Engineering

Linear Algebra: Matrix algebra, Systems of linear equations, Eigen values and eigenvectors.

Calculus: Functions of single variable, Limit, continuity and differentiability, Taylor series, Mean value theorems, Evaluation of definite and improper integrals, Partial derivatives, Total derivative, Maxima and minima, Gradient, Divergence and Curl, Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

Differential equations: First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy's and Euler's equations, Initial and boundary value problems, Laplace transforms, Solutions of one dimensional heat and wave equations and Laplace equation.

Complex variables: Complex number, polar form of complex number, triangle inequality.

Probability and Statistics: Definitions of probability and sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Poisson, Normal and Binomial distributions, Linear regression analysis.

Numerical Methods: Numerical solutions of linear and non-linear algebraic equations. Integration by trapezoidal and Simpson's rule. Single and multi-step methods for numerical solution of differential equations.

Petroleum Exploration: Classification and description of some common rocks with special reference to clastic and nonclastic reservoir rocks. Origin, migration and accumulation of Petroleum. Petroleum exploration methods.

Oil and Gas Well Drilling Technology: Well planning. Drilling method. Drilling rigs Rig operating systems. Drilling fluids function and properties. Drilling fluid maintenance equipment. Oil & gas well cementing operations. Drill bit types and their applications. Drill string & Casing string function, operations, selection & design. Drilling problems, their control & remedies. Directional drilling tools. Directional survey. Application of horizontal, multilateral, extended reach, slim wells.

Reservoir Engineering: Petrophysical properties of reservoir rocks. Coring and core analysis. Reservoir fluid properties. Phase behavior of hydrocarbon system. Flow of fluids through porous media. Water and gas coning. Reservoir pressure measurements. Reservoir drives, drive mechanics and recovery factors. Reserve estimation &techniques.

Petroleum Production Operations: Well equipments. Well completion techniques. Well production problems and mitigation. Well servicing & Workover operations. Workover & completion fluids. Formation damage. Well stimulation techniques. Artificial lift techniques. Field processing of oil & gas. Storage and transportation of petroleum and petroleum products. Metering and measurements oil & gas. Production system analysis & optimization. Production testing. Multiphase flow in tubing and flow-lines. Nodal system analysis. Pressure vessels, storage tanks, shell and tube heat exchangers, pumps and compressors, LNG value chain.

Offshore Drilling and Production Practices: Offshore oil and gas operations & ocean environment. Offshore fixed platforms, Offshore mobile units, Station keeping methods like mooring & dynamic

positioning system. Offshore drilling from fixed platform, jack-up, ships and semi submersibles. Use of conductors and risers. Offshore well completion. Deep water applications of subsea technology. Offshore production: Oil processing platforms, water injection platforms, storage, SPM and SBM transportation and utilities. Deep water drilling rig. Deep water production system. Emerging deep water technologies.

Petroleum Formation Evaluation: Evaluation of petrophysical of sub-surface formations: Principles applications, advantages and disadvantages of SP, resistivity, radioactive, acoustic logs and types of tools used. Evaluation of CBL/VDL, USIT, SFT, RFT. Production logging tools, principles, limitations and applications. Special type of logging tools. Casing inspection tools (principles, applications and limitations), Formations micro scanner (FMS), NMR logging principles. Standard log interpretation methods. Cross-plotting methods.

Oil and Gas Well Testing: Diffusivity equation, derivation & solutions. Radius of investigation. Principle of superposition. Horner's approximation. Drill Stem Testing. Pressure Transient Tests: Drawdown and build up-test analysis. Wellbore effects. Multilayer reservoirs. Injection well testing. Multiple well testing. Interference testing, Pulse testing, well-test analysis by use of type curves. Gas well testing.

Health Safety and Environment in Petroleum Industry: Health hazards in Petroleum Industry: Toxicity, Physiological, Asphyxiation, respiratory and skin effect of petroleum hydrocarbons, sour gases. Safety System: Manual & automatic shutdown system, blow down systems. Gas detection system. Fire detection and suppression systems. Personal protection system & measures. HSE Policies. Disaster & crisis management in Petroleum Industry. Environment: Environment concepts, impact on eco-system, air, water and soil. The impact of drilling & production operations on environment, Environmental transport of petroleum wastes. Offshore environmental studies. Offshore oil spill and oil spill control. Waste treatment methods.

Enhanced Oil Recovery Techniques: Basic principles and mechanism of EOR, Screening of EOR process. Concept of pattern flooding, recovery efficiency, permeability heterogeneity. Macroscopic and microscopic displacement efficiency. EOR methods: Chemical flooding, Miscible flooding, Thermal recoveries (steam stimulation, hot water & steam flooding, in-situ combustion), Microbial EOR.

Latest trends in Petroleum Engineering: Coal bed methane, shale gas, oil shale, gas hydrate, and heavy oil.

PH	PHYSICS

Section 1: Mathematical Physics

Vector calculus: linear vector space: basis, orthogonality and completeness; matrices; similarity transformations, diagonalization, eigenvalues and eigenvectors; linear differential equations: second order linear differential equations and solutions involving special functions; complex analysis: Cauchy-Riemann conditions, Cauchy's theorem, singularities, residue theorem and applications; Laplace transform, Fourier analysis; elementary ideas about tensors: covariant and contravariant tensors.

Section 2: Classical Mechanics

Lagrangian formulation: D'Alembert's principle, Euler-Lagrange equation, Hamilton's principle, calculus of variations; symmetry and conservation laws; central force motion: Kepler problem and Rutherford scattering; small oscillations: coupled oscillations and normal modes; rigid body dynamics: interia tensor, orthogonal transformations, Euler angles, Torque free motion of a symmetric top; Hamiltonian and Hamilton's equations of motion; Liouville's theorem; canonical transformations: action-angle variables, Poisson brackets, Hamilton-Jacobi equation.

Special theory of relativity: Lorentz transformations, relativistic kinematics, mass-energy equivalence.

Section 3: Electromagnetic Theory

Solutions of electrostatic and magnetostatic problems including boundary value problems; method of images; separation of variables; dielectrics and conductors; magnetic materials; multipole expansion; Maxwell's equations; scalar and vector potentials; Coulomb and Lorentz gauges; electromagnetic waves in free space, non-conducting and conducting media; reflection and transmission at normal and oblique incidences; polarization of electromagnetic waves; Poynting vector, Poynting theorem, energy and momentum of electromagnetic waves; radiation from a moving charge.

Section 4: Quantum Mechanics

Postulates of quantum mechanics; uncertainty principle; Schrodinger equation; Dirac Bra-Ket notation, linear vectors and operators in Hilbert space; one dimensional potentials: step potential, finite rectangular well, tunneling from a potential barrier, particle in a box, harmonic oscillator; two and three dimensional systems: concept of degeneracy; hydrogen atom; angular momentum and spin; addition of angular momenta; variational method and WKB approximation, time independent perturbation theory; elementary scattering theory, Born approximation; symmetries in quantum mechanical systems.

Section 5: Thermodynamics and Statistical Physics

Laws of thermodynamics; macrostates and microstates; phase space; ensembles; partition function, free energy, calculation of thermodynamic quantities; classical and quantum statistics; degenerate Fermi gas; black body radiation and Planck's distribution law; Bose-Einstein condensation; first and second order phase transitions, phase equilibria, critical point.

Section 6: Atomic and Molecular Physics

Spectra of one-and many-electron atoms; spin-orbit interaction: LS and jj couplings; fine and hyperfine structures; Zeeman and Stark effects; electric dipole transitions and selection rules; rotational and vibrational spectra of diatomic molecules; electronic transitions in diatomic molecules, Franck-Condon principle; Raman effect; EPR, NMR, ESR, X-ray spectra; lasers: Einstein coefficients, population inversion, two and three level systems.

Section 7: Solid State Physics

Elements of crystallography; diffraction methods for structure determination; bonding in solids; lattice vibrations and thermal properties of solids; free electron theory; band theory of solids: nearly free electron and tight binding models; metals, semiconductors and insulators; conductivity, mobility and effective mass; Optical properties of solids; Kramer's-Kronig relation, intra- and inter-band transitions; dielectric properties of solid; dielectric function, polarizability, ferroelectricity; magnetic properties of solids; dia, para, ferro, antiferro and ferri-magnetism, domains and magnetic anisotropy; superconductivity: Type-I and Type II superconductors, Meissner effect, London equation, BCS Theory, flux quantization.

Section 8: Electronics

Semiconductors in equilibrium: electron and hole statistics in intrinsic and extrinsic semiconductors; metal-semiconductor junctions; Ohmic and rectifying contacts; PN diodes, bipolar junction transistors, field effect transistors; negative and positive feedback circuits; oscillators, operational amplifiers, active filters; basics of digital logic circuits, combinational and sequential circuits, flip-flops, timers, counters, registers, A/D and D/A conversion.

Section 9: Nuclear and Particle Physics

Nuclear radii and charge distributions, nuclear binding energy, electric and magnetic moments; semi-empirical mass formula; nuclear models; liquid drop model, nuclear shell model; nuclear force and two nucleon problem; alpha decay, beta-decay, electromagnetic transitions in nuclei; Rutherford scattering, nuclear reactions, conservation laws; fission and fusion; particle accelerators and detectors; elementary particles; photons, baryons, mesons and leptons; quark model; conservation laws, isospin symmetry, charge conjugation, parity and time-reversal invariance.

PI	PRODUCTION AND INDUSTRIAL ENGINEERING

Section 1: Engineering Mathematics

Linear Algebra: Matrix algebra, Systems of linear equations, Eigen values and Eigen vectors.

Calculus: Functions of single variable, Limit, continuity and differentiability, Mean value theorems, Evaluation of definite and improper integrals, Partial derivatives, Total derivative, Maxima and minima, Gradient, Divergence and Curl, Vector identities, Directional derivatives; Line, Surface and Volume integrals; Stokes, Gauss and Green's theorems.

Differential Equations: First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy's and Euler's equations, Initial and boundary value problems, Laplace transforms.

Complex Variables: Analytic functions, Cauchy's integral theorem, Taylor series.

Probability and Statistics: Definitions of probability and sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Linear regression, Random variables, Poisson, normal, binomial and exponential distributions.

Numerical Methods: Numerical solutions of linear and nonlinear algebraic equations, Integration by trapezoidal and Simpson's rules, Single and multi-step methods for differential equations.

Section 2: General Engineering

Engineering Materials: Structure, physical and mechanical properties, and applications of common engineering materials (metals and alloys, semiconductors, ceramics, polymers, and composites – metal, polymer and ceramic based); Iron-carbon equilibrium phase diagram; Heat treatment of metals and alloys and its influence on mechanical properties; Stress-strain behavior of metals and alloys.

Applied Mechanics: Engineering mechanics – equivalent force systems, free body concepts, equations of equilibrium; Trusses; Strength of materials – stress, strain and their relationship; Failure theories; Mohr's circle (stress); Deflection of beams, bending and shear stresses; Euler's theory of columns; Thick and thin cylinders; Torsion.

Theory of Machines and Design: Analysis of planar mechanisms, cams and followers; Governors and fly wheels; Design of bolted, riveted and welded joints; Interference/shrink fit joints; Friction and lubrication; Design of shafts, keys, couplings, spur gears, belt drives, brakes and clutches; Pressure vessels.

Thermal and Fluids Engineering: Fluid mechanics – fluid statics, Bernoulli's equation, flow through pipes, laminar and turbulent flows, equations of continuity and momentum, capillary action; Dimensional analysis; Thermodynamics – zeroth, first and second laws of thermodynamics, thermodynamic systems and processes, calculation of work and heat for systems and control volumes; Air standard cycles; Heat transfer – basic applications of conduction, convection and radiation.

Section 3: Manufacturing Processes I

Casting: Types of casting processes and applications; Sand casting: patterns – types, materials and allowances; molds and cores–materials, making, and testing; design of gating system and riser; casting techniques of cast iron, steels, and nonferrous metals and alloys; analysis of solidification and microstructure development; Other casting techniques: Pressure die casting, Centrifugal casting, Investment casting, Shell mold casting; Casting defects and their inspection by non-destructive testing.

Metal Forming: Stress-strain relations in elastic and plastic deformation; von Mises and Tresca yield criteria, Concept of flow stress; Hot, warm and cold working; Bulk forming processes – forging, rolling, extrusion and wire drawing; Sheet metal working processes – blanking, punching, bending, stretch forming, spinning and deep drawing; Ideal work and slab analysis; Defects in metal working and their causes.

Joining of Materials: Classification of joining processes; Principles of fusion welding processes using different heat sources (flame, arc, resistance, laser, electron beam), Heat transfer and associated losses; Arc welding processes - SMAW, GMAW, GTAW, plasma arc, submerged arc welding processes; Principles of solid state welding processes - friction welding, friction stir welding, ultrasonic welding; Welding defects - causes and inspection; Principles of adhesive joining, brazing and soldering processes.

Powder Processing: Production of metal/ceramic powders, compaction and sintering of metals and ceramic powders, Cold and hot isostatic pressing.

Polymers and Composites: Polymer processing – injection, compression and blow molding, extrusion, calendaring and thermoforming; Molding of composites.

Section 4: Manufacturing Processes II

Machining: Orthogonal and oblique machining, Single point cutting tool and tool signature, Chip formation, cutting forces, Merchant's analysis, Specific cutting energy and power; Machining parameters and material removal rate; tool materials, Tool wear and tool life; Thermal aspects of machining, cutting fluids, machinability; Economics of machining; Machining processes - turning, taper turning, thread cutting, drilling, boring, milling, gear cutting, thread production; Finishing processes – grinding, honing, lapping and super-finishing.

Machine Tools: Lathe, milling, drilling and shaping machines – construction and kinematics; Jigs and fixtures – principles, applications, and design.

Advanced Manufacturing: Principles and applications of USM, AJM, WJM, AWJM, EDM and Wire EDM, LBM, EBM, PAM, CHM, ECM; Effect of process parameters on material removal rate, surface roughness and power consumption; Additive manufacturing techniques.

Computer Integrated Manufacturing: Basic concepts of CAD and CAM, Geometric modeling, CNC; Automation in Manufacturing; Industrial Robots – configurations, drives and controls; Cellular manufacturing and FMS - Group Technology, CAPP.

Section 5: Quality and Reliability

Metrology and Inspection: Accuracy and precision; Types of errors; Limits, fits and tolerances; Gauge design, Interchangeability, Selective assembly; Linear, angular, and form measurements (straightness, flatness, roundness, runout and cylindricity) by mechanical and optical methods; Inspection of screw threads and gears; Surface roughness measurement by contact and non-contact methods.

Quality Management: Quality – concept and costs; Statistical quality control – process capability analysis, control charts for variables and attributes and acceptance sampling; Six sigma; Total quality management; Quality assurance and certification - ISO 9000, ISO14000.

Reliability and Maintenance: Reliability, availability and maintainability; Distribution of failure and repair times; Determination of MTBF and MTTR, Reliability models; Determination of system reliability; Preventive and predictive maintenance and replacement, Total productive maintenance.

Section 6: Industrial Engineering

Product Design and Development: Principles of product design, tolerance design; Quality and cost considerations; Product life cycle; Standardization, simplification, diversification; Value engineering and analysis; Concurrent engineering; Design for "X".

Work System Design: Taylor's scientific management, Gilbreths's contributions; Productivity – concepts and measurements; Method study, Micro-motion study, Principles of motion economy; Work measurement – time study, Work sampling, Standard data, PMTS; Ergonomics; Job evaluation and merit rating.

Facility Design: Facility location factors and evaluation of alternate locations; Types of plant layout and their evaluation; Computer aided layout design techniques; Assembly line balancing; Materials handling systems.

Section 7: Operations research and Operations management

Operation Research: Linear programming – problem formulation, simplex method, duality and sensitivity analysis; Transportation and assignment models; Integer programming; Constrained and unconstrained nonlinear optimization; Markovian queuing models; Simulation – manufacturing applications.

Engineering Economy and Costing: Elementary cost accounting and methods of depreciation; Break-even analysis; Techniques for evaluation of capital investments; Financial statements; Activity based costing.

Production control: Forecasting techniques – causal and time series models, moving average, exponential smoothing, trend and seasonality; Aggregate production planning; Master production scheduling; MRP, MRP-II and ERP; Routing, scheduling and priority dispatching; Push and pull production systems, concepts of Lean and JIT manufacturing systems; Logistics, distribution, and supply chain management; Inventory – functions, costs, classifications, deterministic inventory models, quantity discount; Perpetual and periodic inventory control systems.

Project management: Scheduling techniques – Gantt chart, CPM, PERT and GERT.

ST	Statistics

Calculus: Finite, countable and uncountable sets; Real number system as a complete ordered field, Archimedean property; Sequences of real numbers, convergence of sequences, bounded sequences, monotonic sequences, Cauchy criterion for convergence; Series of real numbers, convergence, tests of convergence, alternating series, absolute and conditional convergence; Power series and radius of convergence; Functions of a real variable: Limit, continuity, monotone functions, uniform continuity, differentiability, Rolle's theorem, mean value theorems, Taylor's theorem, L' Hospital rules, maxima and minima, Riemann integration and its properties, improper integrals; Functions of several real variables: Limit, continuity, partial derivatives, directional derivatives, gradient, Taylor's theorem, total derivative, maxima and minima, saddle point, method of Lagrange multipliers, double and triple integrals and their applications.

Matrix Theory: Subspaces of $\Re^n$ and $\mathbb{C}^n$, span, linear independence, basis and dimension, row space and column space of a matrix, rank and nullity, row reduced echelon form, trace and determinant, inverse of a matrix, systems of linear equations; Inner products in $\Re^n$ and $\mathbb{C}^n$, Gram-Schmidt orthonormalization; Eigenvalues and eigenvectors, characteristic polynomial, Cayley-Hamilton theorem, symmetric, skew-symmetric, Hermitian, skew-Hermitian, orthogonal, unitary matrices and their eigenvalues, change of basis matrix, equivalence and similarity, diagonalizability, positive definite and positive semi-definite matrices and their properties, quadratic forms, singular value decomposition.

Probability: Axiomatic definition of probability, properties of probability function, conditional probability, Bayes' theorem, independence of events; Random variables and their distributions, distribution function, probability mass function, probability density function and their properties, expectation, moments and moment generating function, quantiles, distribution of functions of a random variable, Chebyshev, Markov and Jensen inequalities.

Standard discrete and continuous univariate distributions: Bernoulli, binomial, geometric, negative binomial, hypergeometric, discrete uniform, Poisson, continuous uniform, exponential, gamma, beta, Weibull, normal.

Jointly distributed random variables and their distribution functions, probability mass function, probability density function and their properties, marginal and conditional distributions, conditional expectation and moments, product moments, simple correlation coefficient, joint moment generating function, independence of random variables, functions of random vector and their distributions, distributions of order statistics, joint and marginal distributions of order statistics; multinomial distribution, bivariate normal distribution, sampling distributions: central, chi-square, central t, and central F distributions.

Convergence in distribution, convergence in probability, convergence almost surely, convergence in r-th mean and their inter-relations, Slutsky's lemma, Borel-Cantelli lemma; weak and strong laws of large numbers; central limit theorem for i.i.d. random variables, delta method.

Stochastic Processes: Markov chains with finite and countable state space, classification of states, limiting behaviour of n-step transition probabilities, stationary distribution, Poisson process, birth-and-death process, pure-birth process, pure-death process, Brownian motion and its basic properties.

Estimation: Sufficiency, minimal sufficiency, factorization theorem, completeness, completeness of exponential families, ancillary statistic, Basu's theorem and its applications, unbiased estimation, uniformly minimum variance unbiased estimation, Rao-Blackwell theorem, Lehmann-Scheffe theorem, Cramer-Rao inequality, consistent estimators, method of moments estimators, method of maximum likelihood estimators and their properties; Interval estimation: pivotal quantities and confidence intervals based on them, coverage probability.

Testing of Hypotheses: Neyman-Pearson lemma, most powerful tests, monotone likelihood ratio (MLR) property, uniformly most powerful tests, uniformly most powerful tests for families having MLR property, uniformly most powerful unbiased tests, uniformly most powerful unbiased tests for exponential families, likelihood ratio tests, large sample tests.

Non-parametric Statistics: Empirical distribution function and its properties, goodness of fit tests, chi-square test, Kolmogorov-Smirnov test, sign test, Wilcoxon signed rank test, Mann-Whitney U-test, rank correlation coefficients of Spearman and Kendall.

Multivariate Analysis: Multivariate normal distribution: properties, conditional and marginal distributions, maximum likelihood estimation of mean vector and dispersion matrix, Hotelling's T^2 test, Wishart distribution and its basic properties, multiple and partial correlation coefficients and their basic properties.

Regression Analysis: Simple and multiple linear regression, R^2 and adjusted R^2 and their applications, distributions of quadratic forms of random vectors: Fisher-Cochran theorem, Gauss-Markov theorem, tests for regression coefficients, confidence intervals.

TF Textile Engineering and Fibre Science

ENGINEERING MATHEMATICS

Linear Algebra: Matrices and Determinants; Systems of linear equations; Eigenvalues and Eigenvectors.

Calculus: Limit, continuity and differentiability; Successive differentiation; Partial differentiation; Maxima and minima; Errors and approximations; Definite and improper integrals; Sequences and series; Test for convergence; Power series; Taylor series.

Differential Equations: First order linear and non-linear differential equations; Higher order linear differential equations with constant coefficients; Euler-Cauchy equation; Partial differential equations; Wave and heat equations; Laplace's equation.

Probability and Statistics: Random variables; Poisson, binomial and normal distributions; Mean, mode, median, standard deviation; Confidence interval; Test of hypothesis; Correlation analysis; Regression analysis; Analysis of variance; Control charts.

Numerical Methods: Numerical solutions of linear and non-linear algebraic equations; Numerical integration by trapezoidal and Simpson's rules; Single-step and multi-step numerical methods for differential equations.

TEXTILE ENGINEERING AND FIBRE SCIENCE

Section 1: Textile Fibres

Classification of textile fibres; Essential requirements of fibre forming polymers; Gross and fine structures of natural fibres like cotton, wool, silk; Introduction to bast fibres; Properties and uses of natural and man-made fibres including carbon, aramid and ultra-high molecular weight polyethylene fibres; Physical and chemical methods of fibre and blend identification and blend analysis.

Molecular architecture, amorphous and crystalline phases, glass transition, plasticization, crystallization, melting, factors affecting T_g and T_m; Polymerization of nylon-6, nylon-66, poly (ethylene terephthalate), polyacrylonitrile and polypropylene; Melt spinning processes for PET, polyamide and polypropylene; Preparation of spinning dope; Principles of wet spinning, dry spinning, dry-jet-wet spinning and gel spinning; Spinning of acrylic, viscose and other regenerated cellulosic fibres such as polynosic and lyocell; Post spinning operations such as drawing, heat setting, tow-to-top conversion;Spin finish composition and applications; Different texturing methods.

Methods of investigating fibre structure such as density, x-ray diffraction, birefringence, optical and electron microscopy such as SEM and TEM, I.R. spectroscopy, thermal methods such as DSC, DMA, TMA and TGA; Structure and morphology of man-made fibres; Mechanical properties of fibres; Moisture sorption of fibres; Fibre structure-property correlation.

Section 2: Yarn Manufacture, Yarn Structure and Properties

Principles of ginning; Principles of opening, cleaning and blending; Working principles of modern blow room machines; Fundamentals of carding; Conventional vs. modern carding machine; Card setting; Card clothing; Periodic mass variation in card sliver; Card auto leveller; Principles of roller drawing; Roller arrangements in drafting systems; Periodic mass variation in drawn sliver; Draw frame auto leveller; Principles of cotton combing; Combing cycle and mechanisms; Recent developments in combing machine; Principles of drafting, twisting, and bobbin building in roving formation; Modern developments in roving machine; Principles of drafting, twisting and cop building in ring spinning; Causes of end breakages; Modern developments in ring spinning machine; Working principles of ring doubler and two-for-one twister; Relationship between single yarn twist and folded yarn twist; Principles of compact, rotor, air-jet, air-vortex, friction, core, wrap and twist-less spinning processes.

Influence of fibre geometry, fibre configuration and fibre orientation in yarn; Fibre packing density of yarn; Yarn diameter; Yarn twist and its relation to yarn strength; Helical arrangement of fibres in yarns; Yarn contraction; Fibre migration in yarns; Stress-strain relation in yarn; Mass irregularity of yarn; Structure-property relationship in ring, compact, rotor, air-jet and friction spun yarns.

Section 3: Fabric Manufacture, Structure and Properties

Principles of winding processes; Classification of winding methods; Patterning mechanism; Yarn clearers and tensioners; Different systems of yarn splicing; Warping objectives and classification; Different types of warping creels; Features of beam and sectional warping machines; Different sizing systems; Sizing of spun and filament yarns;Drawing-in process; Principles of pirn winding.

Primary and secondary motions of loom; Shedding motion; Positive and negative shedding mechanisms; Type of sheds; Tappet, dobby and jacquard shedding; Weft insertion; Mechanics of weft insertion with shuttle; Shuttle picking and checking; Beat-up; Kinematics of sley; Loom timing diagram; Cam designing; Effect of sley setting and cam profile on fabric formation; Take-up and Let-off motions; Warp and weft stop motions; Warp protection; Weft replenishment; Principles of weft insertion systems of shuttle-less weaving machines such as projectile, rapier, water-jet and air-jet; Principles of functioning of multiphase and circular looms; Types of selvedges.

Basic woven fabric constructions and their derivatives; Crepe, cord, terry, gauze, leno and double cloth constructions; Drawing and lifting plans.

Fundamentals of weft knitting; Classification of weft knitting technologies; Weft knitted constructions such as plain, rib, interlock and purl; Different knit stitches such as loop, tuck and float.

Principle of warp knitting; Classification of warp knitting technologies; Swinging and shogging motion of guide bar; Basic warp knit construction such as pillar, tricot, atlas, inlay and nets.Fibre preparation processes for nonwovens; Web formation and bonding processes;Spun-bonding and melt-blowing technologies; Applications of nonwoven fabrics.

Principles of braiding; Type of braids; Maypole braiding technology.

Peirce's equations for plain woven fabric geometry; Elastic a model of plain-woven fabric; Thickness, cover and maximum set of woven fabrics; Geometry of plain weft knitted loop; Munden's constants and tightness factor for plain weft knitted fabrics; Geometry of tubular braids.

Section 4: Textile Testing

Sampling techniques for fibres, yarns and fabrics; Sample size and sampling errors.

Moisture in textiles; Fibre length, fineness, crimp, maturity and trash content; Tensile testing of fibres; High volume fibre testing.

Linear density of sliver, roving and yarn; Twist and hairiness of yarn; Tensile testing of yarns; Evenness testing; Fault measurement and analysis of yarns.

Fabric thickness, compressibility, stiffness, shear, drape, crease recovery, tear strength, bursting strength, pilling and abrasion resistance; Tensile testing of fabrics; Objective evaluation of low stress mechanical characteristics; Air permeability; Wetting and wicking; Water-vapour transmission through fabrics; Thermal resistance of fabrics.

Section 5: Chemical Processing

Impurities in natural fibre; Singeing; Chemistry and practice of preparatory processes for cotton; Preparatory processing of wool and silk; Mercerization of cotton; Preparatory processesfor manmade fibres and their blends; Optical brightening agent.

Classification of dyes; Dyeing of cotton, wool, silk, polyester, nylon and acrylic with appropriate classes of dyes; Dyeing of polyester/cotton and polyester/wool blends; Dyeing machines; Dyeing processes and machines for cotton knitted fabrics;Dye-fibre interaction;Introduction to thermodynamics and kinetics of dyeing; Brief idea about the relation between colour and chemical constitution; Beer-Lambert's law;Kubelka-Munk theory and its application in colour measurement; Methods for determination of wash, light and rubbing fastness.

Methods of printing such as roller printing and screen printing; Preparation of printing paste; Various types of thickeners; Printing auxiliaries; Direct styles of printing of (i) cotton with reactive dyes, (ii) wool, silk, nylon with acid and metal complex dyes, (iii) polyester with disperse dyes; Resist and discharge printing of cotton, silk and polyester; Pigment printing; Transfer printing of polyester; Inkjet printing; Printing faults.

Mechanical finishing of cotton; Stiff, soft, wrinkle resistant, water repellent, flame retardant and enzyme (bio-polishing) finishing of cotton; Milling, decatizing and shrink resistant finishing of wool; Antistatic and soil release finishing; Heat setting of synthetic fabrics; Minimum application techniques.

Pollution control and treatment of effluents.

XE - A	Engineering Mathematics (Compulsory for all XE Candidates)

Section 1: Linear Algebra

Algebra of real matrices: Determinant, inverse and rank of a matrix; System of linear equations (conditions for unique solution, no solution and infinite number of solutions); Eigenvalues and eigenvectors of matrices; Properties of eigenvalues and eigenvectors of symmetric matrices, diagonalization of matrices; Cayley-Hamilton Theorem.

Section 2: Calculus

Functions of single variable: Limit, indeterminate forms and L'Hospital's rule; Continuity and differentiability; Mean value theorems; Maxima and minima; Taylor's theorem; Fundamental theorem and mean value theorem of integral calculus; Evaluation of definite and improper integrals; Applications of definite integrals to evaluate areas and volumes (rotation of a curve about an axis).

Functions of two variables: Limit, continuity and partial derivatives; Directional derivative; Total derivative; Maxima, minima and saddle points; Method of Lagrange multipliers; Double integrals

and their applications.

Sequences and series: Convergence of sequences and series; Tests of convergence of series with non-negative terms (ratio, root and integral tests); Power series; Taylor's series; Fourier Series of functions of period 2π.

Section 3: Vector Calculus

Gradient, divergence and curl; Line integrals and Green's theorem.

Section 4: Complex variables

Complex numbers, Argand plane and polar representation of complex numbers; De Moivre's theorem; Analytic functions; Cauchy-Riemann equations.

Section 5: Ordinary Differential Equations

First order equations (linear and nonlinear); Second order linear differential equations with constant coefficients; Cauchy-Euler equation; Second order linear differential equations with variable coefficients; Wronskian; Method of variation of parameters; Eigenvalue problem for second order equations with constant coefficients; Power series solutions for ordinary points.

Section 6: Partial Differential Equations

Classification of second order linear partial differential equations; Method of separation of variables: One dimensional heat equation and two dimensional Laplace equation.

Section 7: Probability and Statistics

Axioms of probability; Conditional probability; Bayes' Theorem; Mean, variance and standard deviation of random variables; Binomial, Poisson and Normal distributions; Correlation and linear regression.

Section 8: Numerical Methods

Solution of systems of linear equations using LU decomposition, Gauss elimination method; Lagrange and Newton's interpolations; Solution of polynomial and transcendental equations by Newton-Raphson method; Numerical integration by trapezoidal rule and Simpson's rule; Numerical solutions of first order differential equations by explicit Euler's method.

XE – B	FLUID MECHANICS

SECTION 1: Flow and Fluid Properties

Fluid Properties: Density, viscosity, surface tension, relationship between stress and strain-rate for Newtonian fluids.

Classification of Flows: Viscous versus inviscid flows, incompressible versus compressible flows, internal versus external flows, steady versus unsteady flows, laminar versus turbulent flows, 1-D, 2-D and 3-D flows, Newtonian versus non-Newtonian fluid flow.

Hydrostatics: Buoyancy, manometry, forces on submerged bodies and its stability.

SECTION 2: Kinematics of Fluid Motion

Eulerian and Lagrangian descriptions of fluid motion. Concept of local, convective and material derivatives. Streamline, streakline, pathline and timeline.

SECTION 3: Integral Analysis for a Control Volume

Reynolds Transport Theorem (RTT) for conservation of mass, linear and angular momentum.

SECTION 4: Differential Analysis

Differential equations of mass and momentum for incompressible flows.

Inviscid flows - Euler equations and viscous flows - Navier-Stokes equations.

Concept of fluid rotation, vorticity, stream function and circulation.

Exact solutions of Navier-Stokes equations for Couette flow and Poiseuille flow, thin film flow.

SECTION 5: Dimensional Analysis

Concept of geometric, kinematic and dynamic similarity.

Buckingham Pi theorem and its applications.

Non-dimensional parameters and their physical significance - Reynolds number, Froude number and Mach number.

SECTION 6: Internal Flows

Fully developed pipe flow.

Empirical relations for laminar and turbulent flows: friction factor, Darcy-Weisbach relation and Moody's chart.

Major and minor losses.

SECTION 7: Bernoulli's Equation and its Applications, Potential Flows

Bernoulli's equation: Assumptions and applications.

Flow measurements - Venturi meter, Pitot-static tube and orifice meter.

Elementary potential flows: Velocity potential function.

Uniform flow, source, sink and vortex, and their superposition for flow past simple geometries.

SECTION 8: External Flows

Prandtl boundary layer equations: Concept and assumptions.

Boundary layer characteristics: Boundary layer thickness, displacement thickness and momentum thickness.

Qualitative idea of boundary layer separation, streamlined and bluff bodies, and drag and lift forces.

XE - C Materials Science

1: Classification and Structure of Materials

Classification of materials: metals, ceramics, polymers and composites.

Nature of bonding in materials: metallic, ionic, covalent and mixed bonding; structure of materials: fundamentals of crystallography, symmetry operations, crystal systems, Bravais lattices, unit cells, primitive cells, crystallographic planes and directions; structures of metals, ceramics, polymers, amorphous materials and glasses.

Defects in crystalline materials: 0-D, 1-D and 2-D defects; vacancies, interstitials, solid solutions in metals and ceramics, Frenkel and Schottky defects; dislocations; grain boundaries, twins, stacking faults; surfaces and interfaces.

2: Thermodynamics, Kinetics and Phase Transformations

Extensive and intensive thermodynamic properties, laws of thermodynamics, phase equilibria, phase rule, phase diagrams (unary and binary), basic electrochemistry.

Reaction kinetics, fundamentals of diffusion, Fick's laws, their solutions and applications.

Solidification of pure metals and alloys, nucleation and growth, diffusional solid-state phase transformations (precipitation and eutectoid), martensitic transformation.

3: Properties and Applications of Materials

Mechanical properties of metals, ceramics, polymers and composites at room temperature; stress-strain response (elastic, anelastic and plastic deformation).

Electronic properties: free electron theory, Fermi energy, density of states, elements of band theory, semiconductors, Hall effect, dielectric behaviour, piezo- and ferro-electric behaviour.

Magnetic properties: Origin of magnetism in materials, para-, dia-, ferro- and ferri-magnetism.

Thermal properties: Specific heat, heat conduction, thermal diffusivity, thermal expansion, and thermoelectricity.

Optical properties: Refractive index, absorption and transmission of electromagnetic radiation.

Examples of materials exhibiting the above properties, and their typical/common applications.

4: Characterization and Measurements of Properties

X-ray diffraction; spectroscopic techniques such as UV-Vis, IR and Raman; optical microscopy, electron microscopy, composition analysis in electron microscopes.

Tensile test, hardness measurement.

Electrical conductivity, carrier mobility and concentrations.

Thermal analysis techniques: thermogravimetry and calorimetry.

5: Processing of Materials

Heat treatment of ferrous and aluminium alloys; preparation of ceramic powders, sintering; thin film deposition: evaporation and sputtering techniques, and chemical vapour deposition, thin film growth phenomena.

6: Degradation of Materials

Corrosion and its prevention; embrittlement of metals; polymer degradation.

XE - D	Solid Mechanics

Section 1: Mechanics of rigid bodies

Equivalent force systems; free-body diagrams; equilibrium equations; analysis of determinate trusses and frames; friction; principle of minimum potential energy; particle kinematics and dynamics; dynamics of rigid bodies under planar motion; law of conservation of energy; law of conservation of momentum.

Section 2: Mechanics of deformable bodies

Stresses and strains; transformation of stresses and strains, principal stresses and strains; Mohr's circle for plane stress and plane strain; generalized Hooke's Law; elastic constants; thermal stresses; theories of failure.

Axial force, shear force and bending moment diagrams; axial, shear and bending stresses; combined stresses; deflection (for symmetric bending); torsion in circular shafts; thin walled pressure vessels; energy methods (Castigliano's Theorems); Euler buckling.

Section 3: Vibrations

Free vibration of undamped single degree of freedom systems.

XE - E Thermodynamics

Section 1: Basic Concepts

Continuum and macroscopic approach; thermodynamic systems (closed and open); thermodynamic properties and equilibrium; state of a system, state postulate for simple compressible substances, state diagrams, paths and processes on state diagrams; concepts of heat and work, different modes of work; zeroth law of thermodynamics; concept of temperature.

Section 2: First Law of Thermodynamics

Concept of energy and various forms of energy; internal energy, enthalpy; specific heats; first law applied to elementary processes, closed systems and control volumes, steady and unsteady flow analysis.

Section 3: Second Law of Thermodynamics

Limitations of the first law of thermodynamics, concepts of heat engines and heat pumps/refrigerators, Kelvin-Planck and Clausius statements and their equivalence; reversible and irreversible processes; Carnot cycle and Carnot principles/theorems; thermodynamic temperature scale; Clausius inequality and concept of entropy; microscopic interpretation of entropy, the principle of increase of entropy, T-s diagrams; second law analysis of control volume; availability and irreversibility; third law of thermodynamics.

Section 4: Properties of Pure Substances

Thermodynamic properties of pure substances in solid, liquid and vapor phases; P-v-T behaviour of simple compressible substances, phase rule, thermodynamic property tables and charts, ideal and real gases, ideal gas equation of state and van der Waals equation of state; law of corresponding states, compressibility factor and generalized compressibility chart.

Section 5: Thermodynamic Relations

T-ds relations, Helmholtz and Gibbs functions, Gibbs relations, Maxwell relations, Joule-Thomson coefficient, coefficient of volume expansion, adiabatic and isothermal compressibilities, Clapeyron and Clapeyron-Clausius equations.

Section 6: Thermodynamic Cycles

Carnot vapor cycle, ideal Rankine cycle, Rankine reheat cycle, air-standard Otto cycle, air-standard Diesel cycle, air-standard Brayton cycle, vapor-compression refrigeration cycle.

Section 7: Ideal Gas Mixtures

Dalton's and Amagat's laws, properties of ideal gas mixtures, air-water vapor mixtures and simple thermodynamic processes involving them; specific and relative humidities, dew point and

wet bulb temperature, adiabatic saturation temperature, psychrometric chart.

XE - F Polymer Science and Engineering

Section 1: Chemistry of high polymers

Monomers, functionality, degree of polymerizations, classification of polymers, glass transition, melting transition, criteria for rubberiness, polymerization methods: addition and condensation; their kinetics, metallocene polymers and other newer methods of polymerization, copolymerization, monomer reactivity ratios and its significance, kinetics, different copolymers, random, alternating, azeotropic copolymerization, block and graft copolymers, techniques for polymerization-bulk, solution, suspension, emulsion. Concept of intermolecular order (morphology) – amorphous, crystalline, orientation states. Factor affecting crystallinity. Crystalline transition. Effect of morphology on polymer properties.

Section 2: Polymer Characterization

Solubility and swelling, Concept of molecular weight distribution and its significance, concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights, polymer crystallinity, analysis of polymers using IR, XRD, thermal (DSC, DMTA, TGA), microscopic (optical and electronic) techniques, Molecular wt. distribution: Broad and Narrow, GPC, mooney viscosity.

Section 3: Synthesis, manufacturing and properties

Commodity and general purpose thermoplastics: PE, PP, PS, PVC, Polyesters, Acrylic, PU polymers. Engineering Plastics: Nylon, PC, PBT, PSU, PPO, ABS, Fluoropolymers Thermosetting polymers: Polyurethane, PF, MF, UF, Epoxy, Unsaturated polyester, Alkyds. Natural and synthetic rubbers: Recovery of NR hydrocarbon from latex; SBR, Nitrile, CR, CSM, EPDM, IIR, BR, Silicone, TPE, Speciality plastics: PEK, PEEK, PPS, PSU, PES etc. Biopolymers such as PLA, PHA/PHB.

Section 4: Polymer blends and composites

Difference between blends and composites, their significance, choice of polymers for blending, blend miscibility-miscible and immiscible blends, thermodynamics, phase morphology, polymer alloys, polymer eutectics, plastic-plastic, rubber-plastic and rubber-rubber blends, FRP, particulate, long and short fibre reinforced composites. Polymer reinforcement, reinforcing fibres – natural and synthetic, base polymer for reinforcement (unsaturated polyester), ingredients / recipes for reinforced polymer composite.

Section 5: Polymer Technology

Polymer compounding-need and significance, different compounding ingredients for rubber and plastics (Antioxidants, Light stabilizers, UV stabilizers, Lubricants, Processing aids, Impact modifiers, Flame retardant, antistatic agents. PVC stabilizers and Plasticizers) and their function, use of carbon black, polymer mixing equipments, cross-linking and vulcanization, vulcanization kinetics.

Section 6: Polymer rheology

Flow of Newtonian and non-Newtonian fluids, different flow equations, dependence of shear modulus on temperature, molecular/segmental deformations at different zones and transitions. Measurements of rheological parameters by capillary rotating, parallel plate, cone-plate rheometer. Visco-elasticity-creep and stress relaxations, mechanical models, control of rheological characteristics through compounding, rubber curing in parallel plate viscometer, ODR and MDR.

Section 7: Polymer processing

Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, filament winding, SMC, BMC, DMC, extrusion, pultrusion, calendaring, rotational molding, thermoforming, powder coating, rubber processing in two-roll mill, internal mixer, Twin screw extruder.

Section 8: Polymer testing

Mechanical-static and dynamic tensile, flexural, compressive, abrasion, endurance, fatigue, hardness, tear, resilience, impact, toughness. Conductivity-thermal and electrical, dielectric constant, dissipation factor, power factor, electric resistance, surface resistivity, volume resistivity, swelling, ageing resistance, environmental stress cracking resistance, limiting oxygen index. Heat deflection temperature –Vicat softening temperature, Brittleness temperature, Glass transition temperature, Co-efficient of thermal expansion, Shrinkage, Flammability, dielectric constant, dissipation factor, power factor, Optical Properties - Refractive Index, Luminous Transmittance and Haze, Melt flow index

Section 9: Polymer Recycling and Waste management

Polymer waste, and its impact on environment, Sources, Identification and Separation techniques, recycling classification, recycling of thermoplastics, thermosets and rubbers, applications of recycled materials. Life cycle assessment of polymer products (case studies like PET bottles, packaging bags)

XE - G Food Technology

Section 1: Food Chemistry and Nutrition

Carbohydrates: structure and functional properties of mono-, oligo-, & poly- saccharides including starch, cellulose, pectic substances and dietary fibre, gelatinization and retrogradation of starch. Proteins: classification and structure of proteins in food, biochemical changes in post mortem and tenderization of muscles. Lipids: classification and structure of lipids, rancidity, polymerization and polymorphism. Pigments: carotenoids, chlorophylls, anthocyanins, tannins and myoglobin. Food flavours: terpenes, esters, aldehydes, ketones and quinines. Enzymes: specificity, simple and inhibition kinetics, coenzymes, enzymatic and non- enzymatic browning. Nutrition: balanced diet, essential amino acids and essential fatty acids, protein efficiency ratio, water soluble and fat soluble vitamins, role of minerals in nutrition, co-factors, anti-nutrients, nutraceuticals, nutrient deficiency diseases. Chemical and biochemical changes: changes occur in foods during different processing.

Section 2: Food Microbiology

Characteristics of microorganisms: morphology of bacteria, yeast, mold and actinomycetes, spores and vegetative cells, gram-staining. Microbial growt h: growth and death kinetics, serial dilution technique. Food spoilage: spoilage microorganisms in different food products including milk, fish, meat, egg, cereals and their products. Toxins from microbes: pathogens and non-pathogens including Staphylococcus, Salmonella, Shigella, Escherichia, Bacillus, Clostridium, and Aspergillus genera. Fermented foods and beverages: curd, yoghurt, cheese, pickles, soya-sauce, sauerkraut, idli, dosa, vinegar, alcoholic beverages and sausage.

Section 3: Food Products Technology

Processing principles: thermal processing, chilling, freezing, dehydration, addition of preservatives and food additives, irradiation, fermentation, hurdle technology, intermediate moisture foods. Food pack aging and storage: packaging materials, aseptic packaging, controlled and modified atmosphere storage. Cereal processing and products: milling of rice, wheat, and maize, parboiling of paddy, bread, biscuits, extruded products and ready to eat breakfast cereals. Oil processing: expelling, solvent extraction, refining and hydrogenation. Fruits and vegetables p processing: extraction, clarification, concentration and packaging of fruit juice, jam, jelly, marmalade, squash, candies, tomato sauce, ketchup, and puree, potato chips, pickles. Plantation crops processing and products: tea, coffee, cocoa, spice, extraction of essential oils and oleoresins from spices. Milk and milk products processing: pasteurization and sterilization, cream, butter, ghee, ice- cream, cheese and milk powder. Processing of animal products: drying, canning, and freezing of fish and meat; production of egg powder. Waste utilization: pectin from fruit wastes, uses of by-products from rice milling. Food standards and quality maintenance: FPO, PFA, A-Mark, ISI, HACCP, food plant sanitation and cleaning in place (CIP).

Section 4: Food Engineering

Mass and energy balance; Momentum transfer: Flow rate and pressure drop relationships for Newtonian fluids flowing through pipe, Reynolds number. Heat transfer: heat transfer by conduction, convection, radiation, heat exchangers. Mass transfer: molecular diffusion and Flick's law, conduction and convective mass transfer, permeability through single and multilayer

films. Mechanical operations: size reduction of solids, high pressure homogenization, filtration, centrifugation, settling, sieving, mixing & agitation of liquid. Thermal operations: thermal sterilization, evaporation of liquid foods, hot air drying of solids, spray and freeze-drying, freezing and crystallization. Mass transfer operations: psychometric, humidification and dehumidification operations.

XE - H	Atmospheric & Ocean Science

Section A: Atmospheric Science

Vertical Structure and Composition of the Atmosphere; Blackbody Radiation and Radiation Balance; Modes of Heat Transfer in the Atmosphere; Greenhouse Effect; Cloud Types; Laws of Thermodynamics; Gas Laws; Hydrostatic Equation; Clausius Clapeyron Equation; Adiabatic Processes, Humidity in the Atmosphere, Atmospheric Stability; Weather and Climate.

Navier-Stokes and Continuity Equations; Compressible and Incompressible Fluids; Pressure Gradient, Centripetal, Centrifugal and Coriolis Forces; Geostrophic, Gradient and Cyclostrophic Balances; Circulations and Vorticity, General Circulation of the Atmosphere. Broad Features of Indian Monsoons, Monsoon Depressions; Tropical Convergence Zones; Tropical Cyclones.

Section B: Ocean Sciences

Vertical Profiles of Temperature and Salinity; Stability and Double Diffusion; Equation of State, Equations for Conservation of Mass, Momentum, Heat and Salt; Inertial Currents; Geostrophic Motion; Air-Sea Surface Fluxes; Wind-driven Circulation, Ekman and Sverdrup Transports; Storm Surges, Tides, Tsunamis and Wind Waves; Eddies and Gyres; Eastern and Western Boundary Currents, Equatorial Currents, Indian Ocean Current Systems; Thermohaline Circulation.

Chemical Properties of Seawater, Major and Minor Elements, Ocean Acidification, Biochemical Cycling of Nutrients, Trace Metals and Organic Matter. Biological Pump; Primary and Secondary Biological Productivity; Air-sea Exchange of Biogenic Dissolved Gases; Marine Ecology.

XH – B1	Reasoning and Comprehension (Compulsory for all XH Candidates)

This part is to test the candidate's ability to comprehend and interpret written information – skills that are critical to research in the Humanities and Social Sciences. The section will not directly test language competence in terms of grammar, vocabulary etc. The focus is instead on critical reasoning (similar to what is often found in exams like LSAT, GRE, GMAT etc.) and analysis of the text and its stylistic and rhetorical structure.

Questions of this section XH-B1 will test the following skills:

• **Reading Comprehension** – ability to understand complex language material in short paragraphs and answer questions regarding them.

• **Expression** – questions on stylistic and rhetorical aspects of a short passage including corrections or modifications of particular sentences.

• **Analytical reasoning** – ability to understand relationships in statements or short passages and being able to draw reasonable conclusions/inferences from them.

• **Logical reasoning** – Thinking critically to evaluate or to predict an argument, identify the main and supporting arguments, predict outcomes etc.

XH - C1 Economics

C1.1 Microeconomics: Theory of Consumer Behaviour: Cardinal Approach and Ordinal Approach; Consumer Preferences; Nature of the utility function; Marshallian and Hicksian demand functions; Duality Theorem. Slutsky equation and Comparative Statics. Homogeneous and Homothetic Utility Functions; Euler's Theorem. The Theory of Revealed Preference: Weak Axiom of Revealed Preference and Strong Axiom of Revealed Preference, Theory of Production and Costs: Short-run and Long-run Analysis, Existence, Uniqueness and Stability of Market Equilibrium: Walrasian and Marshallian Stability Analysis. The Cobweb Model, Decision making under uncertainty and risk. Asymmetric Information: Adverse Selection and Moral Hazard. Theory of Agency costs. The Theory of Search, Non-Cooperative games: Constant sum game, Mixed Strategy & Pure Strategy, Bayesian Nash Equilibrium, SPNE, Perfect Bayesian Equilibria., Theory of Firm: Market Structures — Competitive and Non-competitive equilibria and their efficiency properties. Structure-Conduct-Performance Paradigm, Factor Pricing: Marginal productivity Theory of Distribution in Perfectly Competitive markets; Theory of Employment in Imperfectly Competitive Markets — Monopolistic Exploitation, General Equilibrium Analysis. Welfare Economics: Fundamental Theorems, Social Welfare Function. Efficiency Criteria: Pareto-Optimality.

C1.2 Macroeconomics: National Income Accounting: Closed Economy Concepts and Measurement and Open Economy Issues, Determination of output and employment: Classical & Keynesian Framework, Theories of Consumption: Absolute Income Hypothesis, Relative Income Hypothesis, Life Cycle Hypothesis, Permanent Income Hypothesis and Robert Hall's Random Walk Model; Investment Function Specifications - Dale Jorgenson's Neoclassical Theory of Capital Accumulation and Tobin's, Keynesian Stabilization Policies, (Autonomous) Multipliers and Investment Accelerator, Demand and Supply of Money, Components of Money Supply, Liquidity Preference and Liquidity Trap, Money Multiplier, Interest Rate determination, Central Banking, Objectives, Instruments (Direct and Indirect) of Monetary Policy, Prudential Regulation, Quantitative Easing (Unconventional Monetary Policy), Commercial Banking, Non-Banking Financial Institutions, Capital Market and its Regulation, Theories of Inflation and Expectations Augmented Phillips Curve, Real Business Cycles, Adaptive Expectations Hypothesis, Rational Expectation Hypothesis and its critique. Closed Economy IS – LM Model and Mundell Fleming Model: Monetary and Fiscal Policy Efficacy. The Impossible Trinity.

C1.3 Statistics, Econometrics and Mathematical Economics: Probability Theory: Concepts of probability, Probability Distributions [Discrete and Continuous], Central Limit Theorem, Index Numbers and Construction of Price Indices, Sampling Methods & Sampling Distribution, Statistical Inferences, Hypothesis Testing, Linear Regression Models and the Gauss Markov Theorem, Heteroscedasticity, Multicollinearity and Autocorrelation, Spurious regressions and Unit roots, Simultaneous Equation Models – recursive and non-recursive. Identification Problem, Differential Calculus and its Applications, Linear Algebra – Matrices, Applications of Cramer's Rule, Static Optimization Problems and Applications, Input-Output Model, Linear Programming, Difference equations and Differential equations with applications

C1.4 International Economics: Theories of International Trade, International Trade under Imperfect Competition, Gains from Trade, Terms of Trade, Trade Multiplier, Tariff and Non-Tariff barriers to trade; Dumping and Anti-Dumping Policies, GATT, WTO and Regional Trade Blocks; Trade Policy Issues, Balance of Payments: Composition, Equilibrium and Disequilibrium and Adjustment Mechanisms, Foreign Exchange Market and Arbitrage, Exchange rate determination, IMF & World Bank.

C1.5 Public Economics: Market Failure and Remedial Measures: Asymmetric Information, Public Goods, Externality, Regulation of Market – Collusion and Consumers' Welfare, Public Revenue: Tax & Non-Tax Revenue, Direct & Indirect Taxes, Progressive and non-Progressive Taxation, Incidence and Effects of Taxation, Public expenditure, Public Debt and its management, Public Budget and Budget Multiplier, Tax Incidence, Fiscal Policy and its implications, Environment as a Public Good, Market Failure and Coase Theorem, Cost-Benefit Analysis.

C1.6 Development Economics: Theories of Economic Development: Adam Smith, David Ricardo, Karl Marx, J. Schumpeter, W. Rostow, Balanced & Unbalanced Growth, Big Push Approach, Indicators of Economic Development: HDI, SDGs, MDGs, Poverty and Inequalities – Concepts and Measurement Issues, Social Sector Development: Health, Education, Gender, Fertility, Morbidity, Mortality, Migration, Child Labor, Age Structure, Demographic Dividend, Models of Economic Growth: Harrod-Domar, Solow, Ramsey, Technical progress – Disembodied & Embodied, Endogenous Growth Models.

C1.7 Indian Economy: Economic Growth in India: Pattern and Structure, Agriculture, Industry & Services Sector: Pattern & Structure of Growth, Major Challenges, Policy Responses, Rural & Urban Development – Issues, Challenges & Policy Responses, Flow of Foreign Capital, Trade Policies, Infrastructure Development: Physical and Social; Public-Private Partnerships, Reforms in Land, Labour and Capital Markets, Poverty, Inequality & Unemployment, Functioning of Monetary Policy in India, Fiscal Policy in the Indian context: Structure of Receipts and Expenditure, Tax reforms-Goods and Services Tax, Issues of Growth and Equity, Fiscal Federalism, Centre-State Financial Relations and Finance Commissions of India; Sustainability of Deficits and Debt, The Fiscal Responsibility and Budget Management Act 2003, Demonetization and aftermath. India's balance of payments, Composition of India's Trade, Competitiveness of India's exports, India's exchange rate policy.

XH – C2	English

C2.1 Multi-genre literatures in English—poetry, the novel and other forms of fiction including the short story, drama, creative non-fiction, and non-fiction prose—with emphasis on the long 19th and 20th centuries

C2.2 Especially in a comparative context, anglophone and in English translation, literatures from India and, extending to some degree, the larger Indian subcontinent

C2.3 Literary criticism and theory; critical and cultural intellectual-traditions and approaches widely referred to and used in the discipline of English

C2.4 History of English literature and English literary studies

C2.5 Research approaches and methodologies, including interpretive techniques responsive to literary forms, devices, concepts, and genres

Note: (i) The five units above list aspects the question paper will include rather than signal separate modules or sections; these five units listed are not necessarily exclusive to each other either. The question paper will also not be divided into sections corresponding to the above aspects; and, (ii) While the paper will test candidates for a reasonable breadth of disciplinary knowledge, it would prioritize conceptual depth and methodological sensitivity demonstrative of disciplinary training over information wherever possible.

XH – C3	Linguistics

C3.1 Language and Linguistics: Language spoken, written and signed; description and prescription; language and cultural heritage; language and social identity; language as an object of inquiry – its structure, units and components; design features; writing systems; biological foundations and language faculty; linguistic competence and performance; levels of grammar; contrast and complementation; rules - context dependent and context free; levels of adequacy for analysis; interdisciplinary approaches; schools of linguistic thought (European, American) and the Indian Grammatical Tradition.

C3.2 Levels of Grammar and Grammatical Analysis:

A. Phonetics and Phonology: vocal tract anatomy; phonation; articulatory parameters; classification of sounds; gestural theory of speech production; cardinal vowels; secondary and co-articulation; suprasegmentals - length, stress, tone, intonation and juncture; IPA; basic physics of sound and of phonation and articulation; acoustic cues for speech sounds; organisation of phones into phonemes; phoneme inventories and cross-linguistic properties; syllable structure and phonological properties; principles of phonological analysis - phonetic similarity, contrastive and complementary distribution, free variation, allophones; linear and non-linear approaches; levels of representation; phonological rules; distinctive features (major class, manner, place, etc.); feature geometry; rule ordering, markedness and unspecified featural values; core principles of lexical phonology, optimality theory, autosegmental phonology and prosodic morphology.

B. Morphology: Concepts of morpheme, morph, allomorph, zero allomorph, conditions on allomorphs; lexeme and word; types of morphemes – structural and functional; affixes vs clitics; grammatical categories; morphological theories - generative, lexicalist, process and distributed morphology; identification of morphemes and parts of speech; alternation; morphophonology; inflection vs. derivation; conjugation and declension; word creation and word formation rules and processes; creativity and productivity, blocking, bracketing paradoxes, constraints on affix ordering; mental lexicon; lexical categories; valency changing operations.

C. Syntax: Basic syntactic units and their types: word, phrase, clause, sentence and their description and generation; grammatical and case relations; key ideas from syntactic theories, Generative Grammars including Minimalist Program, HPSG, Relational Grammar and Lexical Functional Grammar; phrase structure rules (including X-bar theory); universal grammar and cross-linguistic properties; idea of grammaticality judgements; solving the language acquisition problem; diagnostics of structure; syntactic phenomena such as movement, binding, ellipses, case-checking, islands, argument structure etc.; unergatives and unaccusatives.

D. Semantics and Pragmatics: Types of meaning, lexical and compositional; syntax-semantics interface (semantic roles, binding, scope, LF etc.);sense and reference, connotation and denotation, lexical semantic relations (homonymy, hypo/hypernymy, antonymy, synonymy, ambiguity); prototype theory and componential analysis; sentence meaning and truth conditions, contradictions, entailment; basic set theory; propositions, truth values, sentential connectives; arguments, predicates, quantifiers, variables; in/definiteness, mood and modality; language use in context; sentence meaning and utterance meaning; speech acts; deixis; presupposition and implicature: Gricean maxims; information structure; politeness, power and solidarity; discourse analysis.

C3.3 Historical Linguistics: Neogrammarian laws of phonetic change such as Grimm's, Verner's, Grassmann's Laws; genesis and spread of sound change; split and merger; conditioned vs. unconditioned change; lexical diffusion of sound change; analogical changes and paradigm levelling; relative chronology of different changes; study of sound change in progress; morphosyntactic (syncretism, grammaticalisation and lexicalisation) and semantic change (extension, narrowing, figurative speech); linguistic reconstruction - external vs. internal: the comparative method; lexicostatistics; language contact and dialect geography – borrowing and impact of borrowing; pidgins and creoles; bi- and multilingualism as the source for borrowing; dialect geography - dialect atlas; isogloss, focal, transition and relic areas.

C3.4 Sociolinguistics: Micro-and macro approaches to language in society; linguistic repertoire language, dialect, sociolect, idiolect; diglossia; taboo, slang and euphemism; elaborated and restricted codes; speech community and communicative competence; ethnography of speaking; lingua franca; diasporic language; linguistic variables and their co-variation along linguistic/social dimensions; language policies and development (especially in India); language contact and outcomes (language loss, pidginization and creolization); code-mixing and code-switching; language movements – state and societal interventions; script development and modifications; linguistic minorities; language ecology and endangerment linguistic vitality, language endangerment (EGIDS scale), parameters of endangerment, documentation and revitalisation.

C3.5 Areal Typology, Universals, Cross-linguistic Features: morphological types of languages agglutinative, analytical (isolating), synthetic fusional (inflecting), polysynthetic (incorporating) languages; formal and substantive universals, absolute and statistical universals; implicational and non-implicational universals (Greenberg); linguistic relatedness—genetic, typological and areal classification of languages; universals and parametric variation; word order typology; salient features of South Asian languages - Indo-Aryan, Dravidian, Austro-Asiatic, and Tibeto-Burman language families; Linguistic Survey of India; contact induced typological change.

C3.6 Methods of analysis:
Experimental and non-experimental methods; sampling and tools; identification of variables and their variants; data processing and interpretation; quantitative analysis of data; ethnomethodology; participant observation; field methods and elicitation; document creation; ethics.

C3.7 Applied Linguistics
(Can be expanded to include Interdisciplinary areas that focus on language and Language Teaching depending on interest and requirement.)

Example: Psycholinguistics: the study of how humans learn, represent, comprehend, and produce language. Topics include word recognition and storage, sentence production and comprehension, reading, speech perception, language acquisition, neural representation of language, bilingualism, and language disorders.

XH – C4 Philosophy

C4.1 Classical Indian Philosophy

C4.1.1 Orthodox Systems: Sānkhya- Puruṣa, Prakṛti, Guṇas, Satkāryavāda, Mokṣa (Kaivalya), Pramāṇas and Theory of Error, **Yoga** – Pramāṇas, Theory of Error, Iśvara, Citta, Kleśa, Aṣṭānga-yoga, Kaivalya (Mokṣa), **Nyāya** – Pramāṇas, Hetvābhāsa, Iśvara, Asatkāryavāda, Theory of Error, Navya-Nyāya, **Vaiśeṣika** – Parataḥprāmāṇya, Padārthas (categories), Theory of Atomism (paramāṇuvāda), **Mīmāmsā** – Dharma, Apūrva, Mokṣa, Pramāṇas (both in Kumārila and Prabhākara), Anyathākhyāti, and, **Vedānta** – Advaita (Adhyāsa, Brahman, Iśvara, Ātman, Jīva, Mokṣa, Viśiṣṭādvaita (Tattva-traya, Mokṣa, and Refutation of Māyāvāda), Dvaita, Dvaitādvaita, Śuddhādvaita, Pramāṇa in Advaita and Viśiṣṭādvaita.

C4.1.2 Heterodox Systems: Cārvāka – Pramāṇa, Indian marerislism and Hedonism, **Jainism**-Pramāṇas, Syādvāda, Anekāntavāda, Padārtha (categories), Jīva and Ajīva, Mokṣa, Mahāvrata, Aṇuvrata, and, **Buddhism** – Ti-piṭaka, Sarvāstivāda, Sautrāntika, Mādhyamika, Yogācāra-Vijñānavāda, Pañca-skandha, Anityavāda, Anātmavāda, Doctrine of Momentariness, Doctrine of Dependent Origination, Pramānas, Doctrine of Two Truths, Doctrine of Tri-kāya, Ṣaḍ-pāramitās, Brahmavihāras, Pāñcaśīla, and Bodhisattva Ideal, and Upāyakauśalya.

C4.1.3 Upaniṣads, Bhagavadgītā, and Dharmaśāstras: Philosophy of the Upaniṣads – Pure Monism, Brahmam and Ātman, Pañca-kośa, Parā-vidyā and Aparā-vidyā, Meaning of Dharma, Ṛta, Puruṣārtha, Śreyas and Preyas, Varṇāśrama-dharma, Dharma- Svadharma and Sādhāraṇa Dharma, Ṛna, Yajña, Karma-yoga, Sthitaprajña, Lokasaṃgraha, and Law of Karma.

C4.1.4 Kāṣmira Śaivism, Śaivasiddhānta, Vīra Śaivism, Śāktism and Vaiṣṇavism: Kāṣmīra Śaivism – Pratyābhijña school, Śiva and Śakti, and Conception of Kriyā, Śaivasiddhānta – God (pati) and Divine Power (śakti), Proofs for God's Existence, Bondage and Liberation, Vīra Śaivism – Philosophical basis of Vīra Śaivism, Śāktism - Philosophical basis of Śāktism, and Vaiṣṇavism – Philosophical basis of Vaiṣṇavism.

C4.2 Contemporary Indian Philosophy

C4.2.1 Vivekananda: Notion of God, Freedom and Karma, Nature of Soul/self, Practical Vedanta, and Universal Religion. **Aurobindo**: World Process – Involution and Evolution, Four Theories of Existence, The Supermind, Integral Yoga, and Gnostic Being. **Iqbal**: Nature of Intuition, Nature of Self, and Notion of God. **Tagore**: Humanism and Nature of Man, Notion of Religion, and Nationalism. **K. C. Bhattacharyya**: Concept of Absolute and Its Alternative Forms, and Notion Subjectivity and Freedom. **Radhakrishnan:** Nature of Ultimate Reality, Religious Experience, Intellect and Intuition, Hindu View of Life. **J. Krishnamurti**: Notion of Freedom, Choiceless Awareness, Truth is a Pathless Land, and Notion of Education. **Gandhi**: Notion of Truth, Non-violence, Satyagraha, Swaraj, and Trusteeship. **Ambedkar:** Annihilation of Caste, Neo-Buddhism, Democracy, and Natural Rights and Law. **M. N. Roy**: Radical Humanism and Materialism.

C4.3 Classical and Modern Western Philosophy

C4.3.1 Metaphysics: Pre-Socratic Philosophy of Thales, Anaxagoras, Anaximenies, Ionians, Pythagoras, Parmenides, Heraclitus and Democritus. Metaphysics of Plato and Aristotle**:** The question of Being (to on/ousia): Being as Idea in Plato's Phaedo, Republic and the Sophist, Being as synthesis of hyle [matter] and morphe [form] in Aristotle's Metaphysics and Physics. Problem of evil and existence of God in St. Augustine, St. Anselm, and St. Thomas Aquinas Metaphysics in Modern Philosophy: Substance, Mind-Body Dualism, Attribute, Parallelism, Pre-established harmony, the existence of God, Problem of Solipsism, Self and Personal Identity, Rejection of Metaphysics, Phenomena and Noumena, Transcendental Deduction of Categories, Being and Becoming, Absolute Idealism

C4.3.2 Epistemology: Plato and Aristotle's Theory of Knowledge, *Doxa*, *Episteme*, and Sophia, Method of Dialectics, Theoretical and Practical Reason, Theory of Causation, Descarte's Method of Doubt, cogito ergo sum, Innate Ideas and its refutation, Principle of Non-contradiction, Sufficient Reason, and Identity of Indiscernible, Locke's Three Grades of Knowledge, Berkeley's Critique of Abstract Ideas, Hume's Impressions and Ideas, Induction and Causality, Kant's Copernican Revolution, Forms of Sensibility, Possibility of Synthetic a priori Judgments. Hegel's Dialectics, Spirit, and Absolute Idealism.

C4.3.3 Ethics: Concepts of Good, Right, Justice, Duty, Obligation, Cardinal Virtues, *Eudaemonism*; Intuition as explained in Teleological and Deontological Theories; Egoism, Altruism, Universalism, Subjectivism, Cultural Relativism, Super-naturalism, Ethical realism and Intuitionism, Kant's moral theory, Postulates of Morality, Good-will, Categorical Imperative, Duty, Means and ends, Maxims; Utilitarianism: Principle of Utility, Problem of Sanction and Justification of Morality, Moral theories of Bentham, J. S. Mill, Sidgwick; Theories of Punishment; Ethical Cognitivism and Non-cognitivism, Emotivism, Prescriptivism, Descriptivism.

C4.3.4 Social and Political Philosophy: Plato's theory of Justice and State, Aristotle's definition of State and Political Naturalism; Classical Liberalism and Social Contract Theory (Hobbes, Rousseau, Locke); Marx's Dialectical Materialism, Alienation, and critique of Capitalism.

C4.3.5 Logic: Truth and Validity, Nature of Propositions, Categorical Syllogism, Laws of Thought Classification of Propositions Square of Opposition, Truth-Functions and Propositional Logic, Quantification and Rules of Quantification; Symbolic Logic: Use of symbols; Truth Table for testing the validity of arguments; Differences between Deductive and Inductive Logic, Causality and Mill's Method.

C4.4 Contemporary Western Philosophy

C4.4.1 Frege's Sense and Reference; Logical Positivism's Verification theory of meaning, Elimination of Metaphysics; Moore's Distinction between Sense and Reference, Defense of common-sense, Proof of an External World; Russell's Logical Atomism, Definite Descriptions, Refutation of Idealism; Wittgenstein on Language and Reality, the Picture Theory, critique of private language, Meaning and Use, Forms of life; Gilbert Ryle on Systematically Misleading Expressions, critique of Cartesian dualism; W.V.O. Quine's Two Dogmas of Empiricism; P.F. Strawson's concept of Person; Husserl's Phenomenological Method, Philosophy as a rigorous science, Intentionality, Phenomenological Reduction, Inter-subjectivity; Heidegger's concept of Being (*Dasein*), Being in the

world; Sartre's Concept of Freedom, Bad-faith, Humanism; Merleau-Ponty on Perception, Embodied Consciousness; William James's Pragmatic Theories of Meaning and Truth, Varieties of Religious experience; John Dewey on Pragmatist Epistemology with focus on Inquiry, fallibilism and Experience, Education; Nietzsche on the Critique of Enlightenment, Will to Power, Genealogy of Moral; Richard Rorty's Critique of Representationalism, Against Epistemological method, Edifying Philosophy, Levinas: Ethics as a first philosophy, Philosophy of 'other'; Rawls' Veil of Ignorance, Principle of Justice; Nozick's critique of Rawls, Libertarianism: Charles Taylor's Communitarianism, critique of the Liberal Self, Politics of recognition; Martha Nussbaum's Liberal Feminism and Capability Approach; Simone de Beauvoir on Situated Freedom and Ethics of Ambiguity; Code and Harding on Situated Knowledge and Strong and Weak Objectivity; Gilligan and Noddings on Ethics of Care, Debate between Care and Justice.

XH – C5	Psychology

C5.1 Research Methods and Statistics

C5.1.1 Approaches to research: Philosophical worldviews & criteria involved in approach. Research design: quantitative & qualitative, mixed methods.

C5.1.2 Designing research: Research problems, purpose statement, Variables and Operational Definitions, Hypothesis, Sampling.

C5.1.3 Nature of quantitative & qualitative research: Structured, semi-structured interviewing, self-completion questionnaires (Survey), observation, Experimental, Quasi-experimental, Field studies, Focus groups discussions, Narratives, Case studies, Ethnography.

C5.1.4 Ethics in conducting and reporting research

C5.1.5 Statistics in Psychology: Measures of Central Tendency and Dispersion. Normal Probability Curve. Parametric and Non-parametric tests Effect size and Power analysis.

C5.1.6 Correlational Analysis: Correlation [Product Moment, Rank Order], Partial correlation, multiple correlation. Special Correlation Methods: Biserial, Point biserial, tetrachoric, phi coefficient. Regression: Simple linear regression, Multiple regression. Factor analysis: Assumptions, Methods, Rotation and Interpretation.

C5.1.7 Experimental Designs: ANOVA [One-way, Factorial], Randomized Block Designs, Repeated Measures Design, Latin Square, Cohort studies, Time series, MANOVA, ANCOVA. Single-subject designs.

C5.2 Psychometrics: Foundations of Psychological measurement; Basic components: scales and items' Construction and analysis of items: Intelligence test items, performance tests, Ability & Aptitude test, Personality questionnaires. Method of test construction, Standardization of measures: Reliability, Validity, Norms, Application of assessment and measurements in Tests— Applications of psychological testing in various settings-educations, counselling and guidance, clinical, organizational and developmental.

C5.3 Biological and evolutionary basis of behaviour: Heredity and behaviour Evolution and natural selection, Nervous system, structures of the brain and their functions, Neurons: Structure, functions, types, neural impulse, synaptic transmission. Neurotransmitters. Hemispheric lateralization, The endocrine system types and functions, Biological basis of Motivation: Hunger, Thirst, Sleep and Sex. Biological basis of emotion: The Limbic system, Hormonal regulation of behaviour. Methods of Physiological Psychology: Invasive methods – Anatomical methods, degeneration techniques, lesion techniques, chemical methods, microelectrode studies, Non-invasive methods – EEG, Scanning methods, Muscular and Glandular system: Genetics and behaviour: Chromosomal anomalies; Nature-Nurture controversy [Twin studies and adoption studies]

C5.4 Perception, Learning, Memory and Forgetting: What is sensation, sensory thresholds and sensory adaptations, Vision, hearing, touch and pain, smell and taste, kinesthesis and vestibular sense, Perception: role of attention; organizing principles of perception, gestalt perception, depth perception and illusions, Theories of learning: classical conditioning, operant conditioning, social

learning theory, cognitive learning, Memory: encoding, storage, retrieval, Information processing theories of memory, Retrieval in Long term memory, reconstructive nature of long-term memory, Forgetting: encoding failure, interference theory, memory trace decay theory, the physical aspects of memory.

C5.5 Cognition: Thinking, Intelligence and Language: Basic elements of though: Concepts, Propositions, Imagery. Current paradigms of cognitive psychology – Information processing approach, ecological approach, Problem solving: Methods of problem solving, Strategies and obstacles, Role of Metacognitive processing, decision-making: choosing among alternatives, Intelligence: Theories of intelligence (Spearman; Thurstone; Jensen; Cattell; Gardner; Stenberg) and Emotional Intelligence; Measuring intelligence, Individual differences in Intelligence; Role of heredity and environment, Difference between Intelligence, Aptitude and Creativity.

C5.6 Personality: Theories of personality: Psychoanalytic, behaviourist, social cognitive view, humanism and trait and type theories, Biology of personality and Assessment of personality.

C5.7 Motivation, Emotion and Stress and Coping: Approaches to understanding motivation: instinct, drive-reduction, arousal, incentive, humanistic, Achievement motivation, Intrinsic motivation, aggression, curiosity and exploration, Emotions: nature of emotions; biological basis of emotions, Theories of emotions: James-Lange, Canon-Bard, Schachter and Singer, Lazarus, Definition of stress; what are stressors; cognitive factors in stress, Factors in stress reaction: General adaptation syndrome; effect of stress, Coping with stress: problem-focused coping; emotion-focused coping, REBT and meditation

C5.8 Social psychology: Social perception: Attribution; impression formation; social categorization, implicit personality theory, Social influence: conformity, compliance and obedience, Attitudes, beliefs and values: Evaluating the social world, attitude formation, attitude change and persuasion, cognitive dissonance, Prejudice, discrimination, Aggression, power and prosocial behaviour, Belief systems and value patterns. Group dynamics, leadership style and effectiveness, Theories of intergroup relations and conflicts.

C5.9 Development across the life span: Nature versus nurture in human development, Prenatal development: Chromosomes, Genes and DNA. Physical, cognitive and psychosocial development in infancy, childhood, adolescence and adulthood, Theories of aging, Moral development.

C5.10 Applications of Psychology: Psychological disorders: Conceptions of mental disorders; Assessment and diagnosis, DSM and Other tools, PTSD and Trauma; Psychotherapies: Psychodynamic, Phenomenological/Experiential therapy; Behaviour therapy; cognitive therapy; biological therapy, Applications of theories of motivation and learning in School: Factors in educational achievement; counselling & guidance in schools, Application of theories of motivation, learning, emotions, perceptions, group dynamics & leadership to organizational set up, Issues of Personal space, crowding, and territoriality.

XH – C6 Sociology

C6.1 Sociological Theory

C6.1.1 Classical Sociological Traditions: Emile Durkheim (Social Solidarity, Social Facts, Religion, Functionalism, Suicide, Anomie, Division of Labour, Law; Max Weber (Types of authority, Social action, Protestant ethic and the spirit of capitalism, Bureaucracy, Ideal type, Methodology); Karl Marx: Class and class conflict, dialectical and historical materialism, capitalism, surplus value, alienation)

C6.1.2 Structural-Functionalism and Structuralism: Bronislaw Malinowski; A.R. Radcliffe- Brown, Talcott Parsons (AGIL, Systems approach), Robert K. Merton (Middle range theory, reference groups, latent and manifest function), Claude Levi Strauss (Myths, Structuralism)

C6.1.3 Hermeneutic and Interpretative Traditions: G.H. Mead, Alfred Schutz (Phenomenology); Harold Garfinkel (Ethnomethodology); Erving Goffman (Symbolic interaction, dramaturgy); ·Clifford Geertz (Culture, thick description)

C6.1.4 Post-Modernism, Post-Structuralism and Post-Colonialism: Pierre Bourdieu, Michel Foucault, Jurgen Habermas, Anthony Giddens, Frankfurt School

C6.1.5 Conflict theory: Ralf Dahrendorf; C Wright Mills

C6.1.6 Indian Thinkers, M.K. Gandhi, B.R. Ambedkar, Radha Kamal Mukherjee, G. S. Ghurye, M.N. Srinivas, Irawati Karve,

C6.2 Research Methodology and Methods

C6.2.1 Conceptualizing Social Reality: Philosophy of Science; ·Scientific Method and Epistemology in Social Science; Hermeneutic Traditions; Objectivity and Reflexivity in Social Science; Ethics and Politics of research

C6.2.2 Research Design:·Reading Social Science Research, Data and Documents; Induction and Deduction; Fact, Concept and Theory;·Hypotheses, Research Questions, Objectives

C6.2.3 Quantitative and Qualitative Methods: Ethnography; Survey Method; Historical Method; Comparative Method

C6.2.4 Research Techniques; Sampling; Questionnaire and Schedule; Statistical Analysis; Observation, Interview and Case study; Interpretation, Data Analysis and Report Writing

C6.3 Sociological Concepts

C6.3.1 Sociological Concepts: Social Structure; Culture; Network; Status and Role; Identity; Community; Socialization; Diaspora; Values, Norms and Rules; Personhood, Habitus and Agency; Bureaucracy, Power and Authority; Self and society

C6.3.2 Social Institutions: Marriage, Family and Kinship; Economy; Polity; Religion; Education; Law and Customs

C6.3.3 Social Stratification: Social Difference, Hierarchy, Inequality and Marginalization: Caste and Class; Status and Power; Gender, Sexuality and Disability; Race, Tribe and Ethnicity

C6.3.4 Social Change: Evolution and Diffusion; Modernization and Development; Social Transformations and Globalization; Social Mobility –Sanskritization, Educational and Occupational change

C6.4 Agrarian Sociology and Rural Transformation: Rural and Peasant Society; Caste-Tribe Distinction and Continuum; Agrarian Social Structure and Emergent Class Relations; Land Ownership and Agrarian Relations; Decline of Agrarian Economy, De-Peasantization and Agrarian Change; Agrarian Unrest and Peasant Movements; Feudalism, Mode of production debate; Land reforms; Panchayati Raj; Rural development programmes and community development; Green revolution and agricultural change; Peasants and farmers movements

C6.5 Family, Marriage and Kinship; Theoretical Approaches: Structural-Functionalist, Alliance and Cultural; Gender Relations and Power Dynamics; Inheritance, Succession and Authority; Gender, Sexuality and Reproduction; Children, Youth and Elderly; Emotions and Family; Emergent Forms of Family; Changing Marriage Practices; Changing Care and Support Systems; Family Laws; Domestic Violence and Crime against Women; Honour Killing

C6.6 Indian Society / Sociology of India: Colonial, Nationalist, Indological perspectives (G.S.Ghurye); Structural-Functional approach (M. N. Srinivas); Dialectical approach (A. R. Desai); Subaltern studies (R. Guha); Non Brahmin perspectives (Phule, Dr. Babasaheb Ambedkar); Feminist perspectives (Leela Dube, Sharmila Rege); Social Institutions – Family, Kinship, Household, Village and Urban Settings; Social Stratification – Caste, Class, Tribe and Gender; Tradition and Modernity (M.N.Srinivas, Yogendra Singh, Dipankar Gupta); Peasants and agrarian sociology (Andre Beteille, AR Desai, D.N.Dhanagare); Village studies; Communalism and Secularism

C6.7 Social Movements

C6.7.1 Introduction to social movements: Nature, Definitions, Characteristics; Social Movement and Social Change; Types of social movements (Reform, Rebellion, Revival, Revolution, Insurrection, Counter Movement)

C6.7.2 Theories of Social Movements: Structural –functional; Marxist; Resource Mobilization Theory; New Social Movements

C6.7.3 Social Movement in India with specific reference to social basis, leadership, ideology and actions: Peasant movement; Labour movement; Dalit movement; Women's movement, Environmental movement

C6.7.4 Social Movements, civil society and globalization: Social movement and its relationship with state and civil society; Social movements and impact of globalization: Debates; Issues of citizenship

C6.8 Sociology of Development

C6.8.1 Perspectives on the Study of Development: Definitions and Indices; Liberal, Marxist, and Neo-Marxist Perspectives (Dependency theory, World Systems); Epistemological Critiques of Development

C6.8.2 State and Market: Institutions and ideologies: Planned Development and Society; Globalisation and Liberalization

C6.8.3 The Micro-Politics of Development: Transforming Communities:
Maps and Models; Knowledge and Power in Development; Re-inventing Development: Subaltern Movements; Post-colonial development; Decentralization and devolution; Participatory approaches

C6.8.4 Sustainable development: Post-sustainable development; Development, violence and inequality; Post-structural perspectives (Escobar); Alternative development paradigms; Feminist critique; Human development

XL - P	Chemistry (Compulsory for all XL candidates)

Section 1: Atomic Structure and Periodicity

Planck's quantum theory, wave particle duality, uncertainty principle, comparison between Bohr's model and quantum mechanical model of hydrogen atom, electronic configuration of atoms and ions. Hund's rule and Pauli's exclusion principle.

Periodic table and periodic properties: ionization energy, electron affinity, electronegativity and atomic size.

Section 2: Structure and Bonding

Ionic and covalent bonding, MO and VB approaches for diatomic molecules, VSEPR theory and shape of molecules, hybridization, resonance, dipole moment, structure parameters such as bond length, bond angle and bond energy, hydrogen bonding and van der Waals interactions. Ionic solids, ionic radii and lattice energy (Born-Haber cycle). HSAB principle.

Section 3: s, p and d Block Elements

Oxides, halides and hydrides of alkali, alkaline earth metals, B, Al, Si, N, P, and S. General characteristics of 3d elements. Coordination complexes: valence bond and crystal field theory, color, geometry, magnetic properties and isomerism.

Section 4: Chemical Equilibria

Osmotic pressure, elevation of boiling point and depression of freezing point, ionic equilibria in solution, solubility product, common ion effect, hydrolysis of salts, pH, buffer and their applications. Equilibrium constants (K_C, K_P and K_X) for homogeneous reactions.

Section 5: Electrochemistry

Conductance, Kohlrausch law, cell potentials, EMF, Nernst equation, thermodynamic aspects and their applications.

Section 6: Reaction Kinetics

Rate constant, order of reaction, molecularity, activation energy, zero, first and second order kinetics, catalysis and elementary enzyme reactions. Reversible and irreversible inhibition of enzymes.

Section 7: Thermodynamics

Qualitative treatment of state and path functions, First law, reversible and irreversible processes, internal energy, enthalpy, Kirchoff equation, heat of reaction, Hess's law, heat of formation. Second law, entropy and free energy. Gibbs-Helmholtz equation, free energy change and spontaneity, Free energy changes from equilibrium constant.

Section 8: Structure-Reactivity Correlations and Organic Reaction Mechanisms

Acids and bases, electronic and steric effects, Stereochemistry, optical and geometrical isomerism, tautomerism, conformers and concept of aromaticity. Elementary treatment of SN1, SN2, E1, E2 and radical reactions, Hoffmann/Saytzeff rules, addition reactions, Markownikoff rule and Kharasch effect. Elementary hydroboration reactions. Grignard's reagents and their uses. Aromatic electrophilic substitutions, orientation effect as exemplified by various functional groups. Identification of common functional groups by chemical tests.

Section 9: Chemistry of Biomolecules

Amino acids, proteins, nucleic acids and nucleotides. Peptide sequencing by chemical and enzymatic proteolytic methods. DNA sequencing by chemical and enzymatic methods. Carbohydrates (upto hexoses only). Lipids (triglycerides only). Principles of biomolecule purification-Ion exchange and gel filtration chromatography. Identification of these biomolecules and Beer-Lambert's law.

XL - Q	Biochemistry

Section 1:

Organization of life; Importance of water; Structure and function of biomolecules: Amino acids, Carbohydrates, Lipids, Proteins and Nucleic acids; Protein structure, folding / misfolding and function; Myoglobin, Hemoglobin, Lysozyme, Ribonuclease A, Carboxypeptidase and Chymotrypsin.

Section 2:

Enzyme kinetics, regulation and inhibition; Vitamins and Coenzymes; Bioenergetics and metabolism; Generation and utilization of ATP; Metabolic pathways and their regulation: glycolysis, TCA cycle, pentose phosphate pathway, oxidative phosphorylation, gluconeogenesis, glycogen and fatty acid metabolism; Metabolism of Nitrogen containing compounds: nitrogen fixation, amino acids and nucleotides. Photosynthesis, Calvin cycle.

Section 3:

Biochemical separation techniques: ion exchange, size exclusion and affinity chromatography, centrifugation; Characterization of biomolecules by electrophoresis; DNA- protein and protein – protein interactions; UV-visible and fluorescence spectroscopy; Mass spectrometry.

Section 4:

Cell structure and organelles; Biological membranes; Action potential; Transport across membranes; Membrane assembly and Protein targeting; Signal transduction; Receptor-ligand interaction; Hormones and neurotransmitters.

Section 5:

DNA replication, transcription and translation; DNA damage and repair; Biochemical regulation of gene expression; Recombinant DNA technology and applications: PCR, site directed mutagenesis, DNA-microarray; Next generation sequencing; Gene silencing and editing.

Section 6:

Immune system: Innate and adaptive; Cell of the immune system; Active and passive immunity; Complement system; Antibody structure, function and diversity; B cell and T Cell receptors; B cell and T cell activation; Major histocompatibilty complex; Immunological techniques: Immunodiffusion, immune-electrophoresis, RIA and ELISA, flow cytometry; monoclonal antibodies and their applications.

XL - R	Botany

Section 1: Plant Systematics

Botanical nomenclature, history of plant taxonomy, diversity and classification of plants, APG system of plant classification; phylogenetics and cladistics, molecular taxonomy and DNA barcoding; Centers for plant taxonomy and herbaria in India.

Section 2: Plant Anatomy

Anatomy of root, stem and leaves, floral organs, embryo and young seedlings, Primary and secondary meristems, stellar organization, vascular system and their ontogeny, xylem and phloem structure, secondary growth in plants and wood anatomy, plant cell structure and differences from animal cells.

Section 3: Plant development; cell and tissue morphogenesis

Life cycle of an angiosperm, development of male and female gametophyte; cell fate determination and tissue patterning; spacing mechanisms in trichomes and stomata. Embryogenesis, organization and function of shoot and root apical meristems. Transition to flowering: photoperiodism and vernalization, ABC model of floral organ patterning, pollen germination, double fertilization, seed development; Xylem and phloem cell differentiation, photomorphogenesis; phytochrome, cryptochrome, phototropin. Role of auxin, cytokinin, gibberellins, and brassinosteroids on plant development.

Section 4: Plant physiology and biochemistry

Plant water relations, mechanisms of uptake and transport of water, ions, solutes from soil to plants, apoplastic and symplastic transport mechanisms. Mechanism of stomatal movements, nitrogen metabolism, photosynthesis; C3, C4 and CAM cycles, photorespiration, respiration: glycolysis, TCA cycle and electron transport chain. Plant responses and mechanisms of abiotic stresses including drought, salinity, freezing and heat stress, metal toxicity; role of abscisic acid in abiotic stresses. Structure and function of biomolecules (proteins, carbohydrates, lipids, nucleic acid), enzyme kinetics. Structure and biosynthesis of major plant secondary metabolites (alkaloids, terpenes, phenylpropanoids, flavonoids). Biosynthesis, mechanism of action and physiological effects of auxin, cytokinin, gibberellic acids, brassinosteroid, ethylene, strigolactone, abscisic acid, salicylic and jasmonic acid. Senescence and programmed cell death.

Section 5: Genetics and genomics

Cell cycle and cell division. Principles of Mendelian inheritance, linkage, recombination, genetic mapping; extra chromosomal inheritance; Introduction to epigenetics; gene silencing- transgene silencing, post transcriptional gene silencing, miRNA and siRNA; evolution and organization of eukaryotic genome structure, gene expression, gene mutation and repair, chromosomal aberrations (numerical: euploidy and aneuploidy and structural: deletion, duplication, inversion, translocation), transposons. Model organisms for functional genetics and genomics; Introduction to transcriptomics, proteomics and metabolomics.

Section 6: Plant Breeding, Genetic Modification, Genome Editing

Principles, methods – selection, hybridization, heterosis; male sterility, genetic maps and molecular markers, embryo rescue, haploid and doubled haploids, plant tissue culture: micropropagation, embryo culture and in vitro regeneration, somatic embryogenesis, artificial seed, cryopreservation, somaclonal variation, somatic cell hybridization, marker-assisted selection, gene transfer methods viz. direct and vector-mediated, generation of transgenic plants; Introduction to genome editing: CRISPR/Cas9, Cre-Lox system to generate chimeras; plastid transformation; chemical mutagenesis.

Section 7: Economic and applied Botany

A general account of economically and medicinally important plants- cereals, pulses, plants yielding fibers, timber, sugar, beverages, oils, rubber, pigments, dyes, gums, drugs and narcotics. Economic importance of algae, fungi, lichen and bacteria. Major Indian cash crops. Effect of industrialization on agricultural botany such as plastic on fiber economy. Genetically modified crops and its regulation eg. Bt cotton, Bt brinjal golden rice etc.

Section 8: Plant Pathology

Nature and classification of plant diseases, diseases of important crops caused by fungi, bacteria, nematodes and viruses, and their control measures (chemical and biological) mechanism(s) of pathogenesis, resistance: basal, systemic, induced systemic resistance, gene for gene concept. Molecular detection of pathogens; plant-microbe interactions: symbionts and mycorrhiza, pathogens and pests. Signaling pathways in plant defence response; salicylic acid (SA) and jasmonic acid (JA) in plant-pathogen and plant-herbivore interaction, necrosis; host-parasitic plant interaction (such as Cuscuta).

Section 9: Ecology and Environment

Ecosystems – types, dynamics, degradation, biogeochemical cycles, ecological succession; food webs and energy flow through ecosystem; vegetation types of the world, Indian vegetation types and biogeographical zones, climate and flora endemism; pollution and global climate change, speciation and extinction, biodiversity and conservation strategies, ecological hotspots, afforestation, habitat restoration; plant interactions with other organisms; epiphytes, parasites and endophytes.

XL - S Microbiology

Section 1: Historical Perspective

Discovery of microbial world; Landmark discoveries relevant to the field of microbiology; Controversy over spontaneous generation; Role of microorganisms in transformation of organic matter and in the causation of diseases.

Section 2: Methods in Microbiology

Pure culture techniques; Principles of microbial nutrition; Enrichment culture techniques for isolation of microorganisms; antigen and antibody detection methods for microbial diagnosis; Light-, phase contrast-, fluorescence- and electron-microscopy; PCR, real-time PCR for quantitation of microbes; Next generation sequencing technologies in microbiology.

Section 3: Microbial Taxonomy and Diversity

Bacteria, Archea and their broad classification; Eukaryotic microbes: Yeasts, molds and protozoa; Viruses and their classification; Molecular approaches to microbial taxonomy and phylogeny.

Section 4: Prokaryotic Cells: Structure and Function

Prokaryotic Cells: cell walls, cell membranes and their biosynthesis, mechanisms of solute transport across membranes, Flagella and Pili, Capsules, Cell inclusions like endospores and gas vesicles; Bacterial locomotion, including positive and negative chemotaxis.

Section 5: Microbial Growth

Definition of growth; Growth curve; Mathematical expression of exponential growth phase; Measurement of growth and growth yields; Synchronous growth; Continuous culture; Effect of environmental factors on growth; Bacterial biofilm and biofouling.

Section 6: Control of Micro-organisms

Disinfection and sterilization: principles, methods and assessment of efficacy.

Section 7: Microbial Metabolism

Energetics: redox reactions and electron carriers; Electron transport and oxidative phosphorylation; An overview of metabolism; Glycolysis; Pentose-phosphate pathway; Entner-Doudoroff pathway; Glyoxalate pathway; The citric acid cycle; Fermentation; Aerobic and anaerobic respiration; Chemolithotrophy; Photosynthesis; Calvin cycle; Biosynthetic pathway for fatty acids synthesis; Common regulatory mechanisms in synthesis of amino acids; Regulation of major metabolic pathways.

Section 8: Microbial Diseases and Host Pathogen Interaction

Normal microbiota; Classification of infectious diseases; Reservoirs of infection; Nosocomial infection; Opportunistic infections; Emerging infectious diseases; Mechanism of microbial pathogenicity; Nonspecific defense of host; Antigens and antibodies; Humoral and cell mediated immunity; Vaccines; passive immunization; Immune deficiency; Human diseases caused by viruses, bacteria, and pathogenic fungi.

Section 9: Chemotherapy/Antibiotics

General characteristics of antimicrobial drugs; Antibiotics: Classification molecular mechanism of mode of action and resistance; Antifungal and antiviral drugs.

Section 10: Microbial Genetics

Types of mutation; UV and chemical mutagens; Selection of mutants; Ames test for mutagenesis; Bacterial genetic system: transformation, conjugation, transduction, recombination, plasmids, transposons; DNA repair; Regulation of gene expression: repression and induction; Operon model; Bacterial genome with special reference to *E.coli*; Phage λ and its life cycle; RNA ; mutation in virus genomes, virus recombination and reassortment; Basic concept of microbial genomics.

Section 11: Microbial Ecology

Microbial interactions; Carbon, sulphur and nitrogen cycles; Soil microorganisms associated with vascular plants; Bioremediation; Uncultivable microorganisms; basic concept of metagenomics and metatranscriptomics.

XL - T	Zoology

Section 1: Animal Diversity

Distribution, systematics and classification of animals, phylogenetic relationships (based on classical and molecular phylogenetic tools).

Section 2: Evolution

Origin and history of life on earth, theories of evolution, natural selection, adaptation, speciation.

Section 3: Genetics

Basic Principles of inheritance, molecular basis of heredity, sex determination and sex-linked characteristics, cytoplasmic inheritance, linkage, recombination and mapping of genes in eukaryotes, population genetics, genetic disorders, roles of model organisms in understanding genetic principles.

Section 4: Biochemistry and Molecular Biology

Nucleic acids, proteins, lipids and carbohydrates; replication, transcription and translation, Krebs cycle, glycolysis, enzyme catalysis, hormones and their actions, roles of vitamins and minerals.

Section 5: Cell Biology

Basic principles of cellular microscopy, structure of cell, cytoskeletal organization, cellular organelles and their structure and function, cell cycle, cell division, chromosomes and chromatin structure.

Section 6: Gene expression in Eukaryotes

Eukaryotic genome organization and regulation of gene expression, transposable elements.

Section 7: Animal Anatomy and Physiology

Comparative physiology, the respiratory system, Muscular system, circulatory system, digestive system, the nervous system, the excretory system, the endocrine system, the reproductive system, the skeletal system.

Section 8: Parasitology and Immunology

Nature of parasite, host-parasite relation, protozoan and helminthic parasites, the immune response, cellular and humoral immune response.

Section 9: Development Biology

Gametogenesis, Embryonic development, cellular differentiation, organogenesis, metamorphosis, Model organisms used in developmental biology, genetic and molecular basis of development, stem cells.

Section 10: Ecology

The ecosystem, Animal distribution, ecological niche and its contribution to ecological diversity, the food chain, population dynamics, species diversity, zoogeography, biogeochemical cycles, conservation biology, ecotoxicology.

Section 11: Animal Behaviour

Type of behaviours, courtship, mating and territoriality, instinct, learning and memory, social behaviour across the animal taxa, communication, pheromones, evolution of behavior in animals.

XL - U Food Technology

Section 1: Food Chemistry and Nutrition

Carbohydrates: structure and functional properties of mono-, oligo-, & poly- saccharides including starch, cellulose, pectic substances and dietary fibre, gelatinization and retrogradation of starch. Proteins: classification and structure of proteins in food, biochemical changes in post mortem and tenderization of muscles. Lipids: classification and structure of lipids, rancidity, polymerization and polymorphism. Pigments: carotenoids, chlorophylls, anthocyanins, tannins and myoglobin. Food flavours: terpenes, esters, aldehydes, ketones and quinines. Enzymes: specificity, simple and inhibition kinetics, coenzymes, enzymatic and non- enzymatic browning. Nutrition: balanced diet, essential amino acids and essential fatty acids, protein efficiency ratio, water soluble and fat soluble vitamins, role of minerals in nutrition, co-factors, anti-nutrients, nutraceuticals, nutrient deficiency diseases. Chemical and biochemical changes: changes occur in foods during different processing.

Section 2: Food Microbiology

Characteristics of microorganisms: morphology of bacteria, yeast, mold and actinomycetes, spores and vegetative cells, gram-staining. Microbial growth: growth and death kinetics, serial dilution technique. Food spoilage: spoilage microorganisms in different food products including milk, fish, meat, egg, cereals and their products. Toxins from microbes: pathogens and non-pathogens including Staphylococcus, Salmonella, Shebelle, Escherichia, Bacillus, Clostridium, and Aspergillums genera. Fermented foods and beverages: curd, yoghurt, cheese, pickles, soya-sauce, sauerkraut, idly, dose, vinegar, alcoholic beverages and sausage.

Section 3: Food Products Technology

Processing principles: thermal processing, chilling, freezing, dehydration, addition of preservatives and food additives, irradiation, fermentation, hurdle technology, intermediate moisture foods. Food pack aging and storage: packaging materials, aseptic packaging, controlled and modified atmosphere storage. Cereal processing and products: milling of rice, wheat, and maize, parboiling of paddy, bread, biscuits, extruded products and ready to eat breakfast cereals. Oil processing: expelling, solvent extraction, refining and hydrogenation. Fruits and vegetables processing: extraction, clarification, concentration and packaging of fruit juice, jam, jelly, marmalade, squash, candies, tomato sauce, ketchup, and puree, potato chips, pickles. Plantation crops processing and products: tea, coffee, cocoa, spice, extraction of essential oils and oleoresins from spices. Milk and milk products processing: pasteurization and sterilization, cream, butter, ghee, ice- cream, cheese and milk powder. Processing of animal products: drying, canning, and freezing of fish and meat; production of egg powder. Waste utilization: pectin from fruit astes, uses of by-products from rice milling. Food standards and quality maintenance: FPO, PFA, A-Mark, ISI, HACCP, food plant sanitation and cleaning in place (CIP).

Section 4: Food Engineering

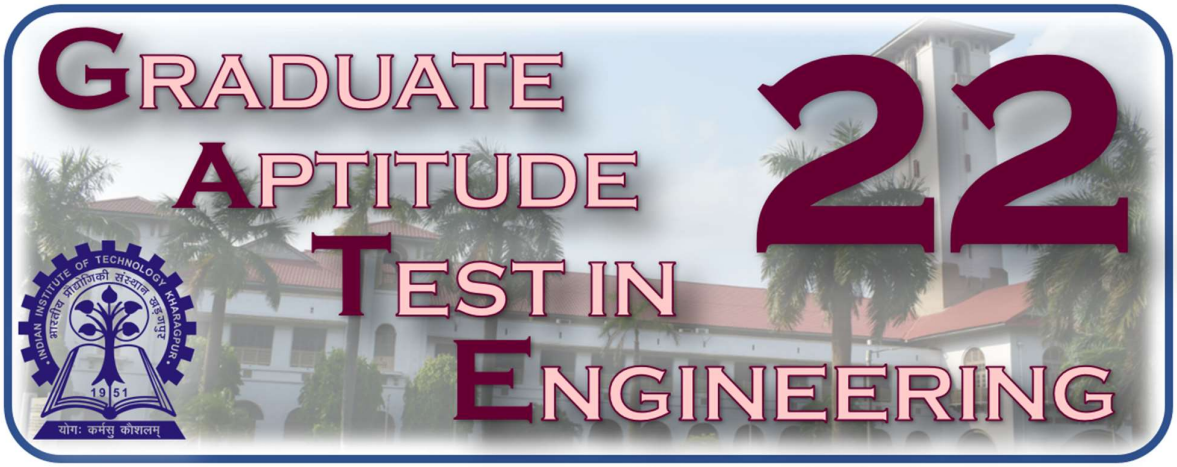
Mass and energy balance: Momentum transfer: Flow rate and pressure drop relationships for Newtonian fluids flowing through pipe, Reynolds number. Heat transfer: heat transfer by conduction, convection, radiation, heat exchangers. Mass transfer: molecular diffusion and Flick's law, conduction and convective mass transfer, permeability through single and multilayer films. Mechanical operations: size reduction of solids, high pressure homogenization, filtration, centrifugation, settling, sieving, mixing & agitation of liquid. Thermal operations: thermal sterilization, evaporation of liquid foods, hot air drying of solids, spray and freeze-drying, freezing and crystallization. Mass transfer operations: psychometric, humidification and dehumidification operations.

Information contained in this brochure is version 1.0 as on 16th June, 2021. There may be some changes in future due to unavoidable reasons. As and when any change happens, it will be notified on GATE 2022 website https://gate.iitkgp.ac.in/

IMPORTANT NOTE

➢In all matters concerning GATE 2022, the decision of the Organising Institute or the Organising Chairperson, GATE 2022 will be final binding on all the applicants.

➢Although GATE 2022 is held at different centres across the country, Indian Institute of Technology Kharagpur is the Organising Institute, and has the overall responsibility of conducting GATE 2022. In case of any claims or disputes arising in respect of GATE 2022, it is hereby made absolutely clear that the Courts in Kolkata alone shall have the exclusive jurisdiction to entertain and settle any such disputes and claims.



Organising Institute

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