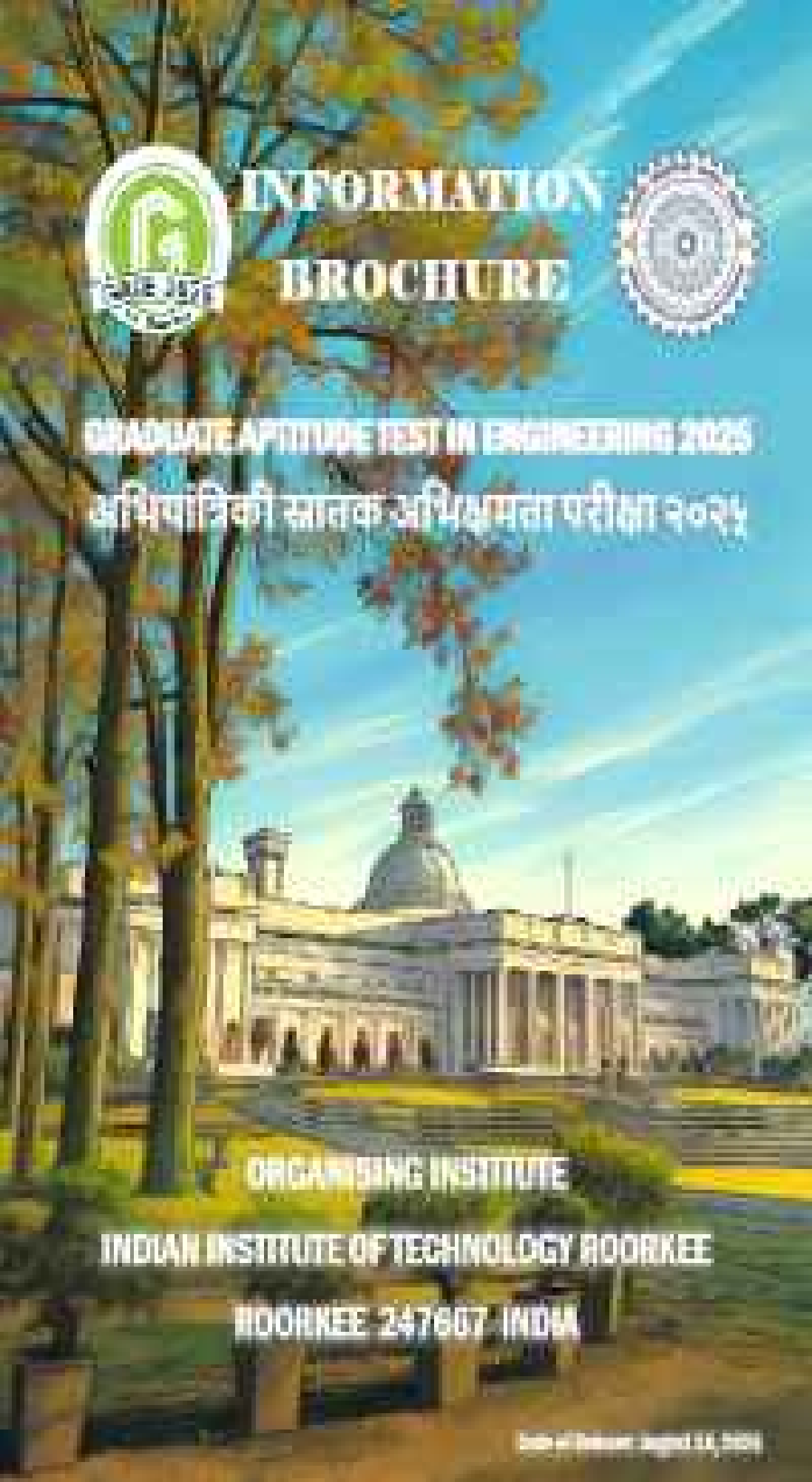
INFORMATION BROCHURE

GRADUATE APTITUDE TEST IN ENGINEERING 2025

अभियांत्रिकी स्नातक अभिक्षमता परीक्षा २०२५



ORGANISING INSTITUTE

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

ROORKEE 247667, INDIA

Date of Release: August 14, 2024

List of Abbreviations

B.A.	Bachelor of Arts	IIT	Indian Institute of Technology
B.Arch.	Bachelor of Architecture	MCQ	Multiple Choice Question
B.Des.	Bachelor of Design	M.E.	Master of Engineering
B.D.S.	Bachelor of Dental Surgery	MoE	Ministry of Education
B.E.	Bachelor of Engineering	M.Sc.	Master of Science
B.Sc.	Bachelor of Science	MSQ	Multiple Select Question
B.Tech.	Bachelor of Technology	M.Tech.	Master of Technology
B.V.Sc.	Bachelor of Veterinary Science	NAT	Numerical Answer Type
CBT	Computer Based Test	NCB	National Coordination Board
CFTI	Centrally Funded Technical Institutes	NIT	National Institute of Technology
EWS	Economically Weaker Section	OBC-NCL	Other Backward Class Non-Creamy Layer
GATE	Graduate Aptitude Test in Engineering	OI	Organizing Institute
GOAPS	GATE Online Application Processing System	Ph.D.	Doctor of Philosophy
GoI	Government of India	PSU	Public Sector Undertaking
[illegible]	[illegible]	PwD	Persons with Disability
ID	Identity Document	SC	Scheduled Caste
IISc	Indian Institute of Science	ST	Scheduled Tribe

Highlights of GATE 2025

- [illegible]
- [illegible]
- GATE 2025 will be conducted as a Computer Based Test (CBT).
- [illegible]
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- [illegible]

The dates mentioned below are liable to change.

Examination Dates	February 1, 2, 15 and 16, 2025	
Dates for ONLINE Registration		
Regular Period	Opening date	August 28, 2024
	Closing date	September 26, 2024
Extended Period	Closing date with late fee	October 7, 2024
Announcement of results		March 19, 2025

Application Fees (per test paper) in ₹

Gender / Category	Regular Period	Extended period
Female / SC / ST / PwD	900*	1400*
Other Candidates	1800*	2300*

Pattern of Examination

Particulars	Details
Mode of examination	Computer Based Test (CBT) The test papers are in English
Duration	3 Hours*
Number of subjects (papers)	[illegible] test papers
Sections	General Aptitude (GA) + Candidate's Selected Subject
Type of questions	(a) Multiple Choice Questions (MCQ) (b) Multiple Select Questions (MSQ) (c) Numerical Answer Type (NAT)
Test of abilities	(a) Recall (b) Comprehension (c) Application (d) Analysis and Synthesis
Number of questions	10 (General Aptitude) + 55 (Subject) = 65 Questions
Distribution of Marks in all papers ([illegible])	General Aptitude: 15 marks + Engineering Mathematics**: 13 marks + Subject Questions: 72 marks Total: 100 marks (**XE includes Engineering Mathematics section [illegible] marks)
Distribution of Marks in papers ([illegible])	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. There is no negative marking for wrong answer(s) to MSQ and NAT questions. There is no partial marking for any question.

*PwD candidates with benchmark disability more than 40% are eligible for compensatory time of 20 minutes/hour. PwD candidates with less than 40% disability and having difficulty in writing are eligible for compensatory time subject to production of a certificate as stated in Appendix of the guidelines issued by the Ministry of Social Justice and Empowerment.

+For details refer Table 6.

Contents

List of Tables

1. Introduction

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[illegible]

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[illegible]

Disclaimer:

[illegible]

2. About GATE

[illegible]

The GATE score would reflect the relative performance level of the candidate in a particular subject. It may be noted that the GATE 2021 score is valid for THREE YEARS from the date of announcement of the results. No information on the GATE 2021 score will be available after this period.

2.1 Administration

GATE is administered jointly by the Indian Institute of Science (IISc), Bengaluru and seven Indian Institutes of Technology (IITs), viz., 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 of 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 1 gives details of the zones and the corresponding administering institutes.

One of the administering institutes is designated as the Organizing Institute (OI), and it would be responsible for the end-to-end process, as well as the coordination amongst the administering institutes for conducting the GATE Examination. The Organizing Institute for GATE 2021 is Indian Institute of Technology Bombay (IITB).

Table 1: Zones and the Corresponding Administrative Institutes for GATE 2021

Zone	Administering Institute	Zonal Website
Zone-1	Indian Institute of Science Bengaluru	http://gate.iisc.ac.in
Zone-2	Indian Institute of Technology Bombay	http://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://gate2021.iitr.ac.in

2.2 Scholarship/ Assistantship for Postgraduate Programs

To avail the financial assistance (scholarship/ assistantship) for the postgraduate program, the candidate must first secure the admission to a program in one of the centrally funded 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, candidates may be admitted directly into a program based on their performance in GATE only or based on their performance in GATE and an admission test and/or interview conducted by the department to which they have applied and/or the candidate's academic record. In the case of admission to master programs, as per the MoE guidelines, a minimum of 70% weightage will be given to the performance in GATE and the remaining 30% will be given to the candidate's performance in test/ interview and/or academic record. However, the admitting institutes could prescribe a minimum passing mark in the test/ interview.

Candidates are advised to seek the relevant details of the admission procedures and the availability of their selected specialization from the corresponding admitting institutions. The criteria for postgraduate admission vary between institutions and hence candidates are advised to check the websites of the admitting institutions before applying. Decisions of the admitting institutions regarding admissions will be based on the policies and norms of the admitting institutions and the Government of India rules.

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

2.2 Several types of scholarships and assistantships are available for the selected candidates. Details may be obtained from the website given against them from the website of Indian Council for Cultural Relations (http://iccr.gov.in).

Note-2(i):

i. Call for admission by M.Tech./M.E. or any other equivalent of graduate and postgraduate by the respective institutions is GATE Examination. GATE organizing do not any admission process.

ii. GATE score of Paper-XE/XT will be formerly used for admission/ recruitment/ assistantship/ award of scholarship/ assistantship.

iii. No right to claim a seat from any IIT/ IISc/ other participating institutions.

2.3 Use of GATE Score for Employment:

In Private sector/Public Sector Undertaking (PSUs) has used GATE score in short list the candidates for employment. A few such organizations are Airports Authority of India (AAI), Bharat Heavy Electricals Limited (BHEL), Bharat Sanchar Nigam Limited (BSNL), Coal India Limited (CIL), Centre for Railway Information Systems (CRIS), Oil and Natural Gas Corporation Limited (ONGC), Damodar Valley Corporation (DVC), Engineers India Limited (EIL), Indian Oil Corporation Limited (IOCL), Mangalore Chemicals and Fertilizers Limited (MCFL), National Aluminium Company Limited (NALCO), National Fertilizers Limited (NFL), Neyveli Lignite Corporation Limited (NLC), Oil India Limited (OIL), Power Grid Corporation of India Limited (PGCIL), Rural Electrification Corporation Limited (REC), Steel Authority of India Limited (SAIL), and Water and Power Consultancy Services (India) Limited (WAPCOS) etc.

Some of the PSUs like Bharat Heavy Electricals Limited, i.e., Senior Field Officer (Trg), Senior Research Officer (Engg), and Senior Research Officer (S&T) in Diploma Technician, Government of India, a merit list is prepared based on the GATE score. The details of the scheme of recruitment are normally published in National Employment News/ Rojgar Samachar by the concerned authority.

Some other Government of India Organizations may also utilize GATE 2020 score for their recruitment purposes.

Disclaimer: GATE is a mechanism to assess a candidate's aptitude for the mentioned examination and the assessment does not guarantee admission/ employment in any organization. The qualified candidates must check the relevant websites and other media sources for any such information. The candidates are advised to verify all facts and claims before applying to any organization.

Note 2.3: The GATE score shall be valid for the two (2) years from the date of declaration of the result. The GATE score may be used for admission/ recruitment in the year(s).

3. About GATE 2025

- IIT Roorkee is the organizing institute for GATE 2025.
- Information website for GATE 2025: https://gate2025.iitr.ac.in
- GATE 2025 will be conducted for 30 subjects (also referred to as "test papers").
- Examination for all the 30 test papers (subjects) will be conducted as Computer Based Test (CBT).
- The Computer Based Test 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 option(s) out of four options is/are correct, and/or (iii) Numerical Answer 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 ONE or TWO test papers of the GATE examination. However, note that the combination of TWO test papers in which a candidate can appear MUST be selected from the pre-defined list as given in Table 3. Even if a candidate is appearing for TWO test papers, the candidate should fill ONLY ONE application form.
- GATE 2025 examinations will be held during the forenoon and afternoon sessions on Saturday 1st, Sunday 2nd, Saturday 15th and Sunday 16th of February 2025.
- Examination for some of the test papers in GATE 2025 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 examination schedule will be notified later on the GATE 2025 website (https://gate2025.iitr.ac.in).
- Important dates for GATE 2025 are given in Table 2.

Table 2: Important Dates

Event	Day	Date
GATE Online Application Processing System (GOAPS) opens	Saturday	August 24, 2024
Closing date of regular online registration/application	Thursday	September 26, 2024
End of extended period for online registration/application (with late fee)	Monday	October 7, 2024
Last date for change of Category, Paper and Examination City, adding a new test paper, and change of personal details (additional fee applicable on change)	Wednesday	November 6, 2024
Admit Card available for download	Thursday	January 2, 2025
GATE 2025 Examination Dates Forenoon: 9:30 AM to 12:30 PM (IST) Afternoon: 2:30 PM to 5:30 PM (IST)	Saturday Sunday Saturday Sunday	February 1, 2025 February 2, 2025 February 15, 2025 February 16, 2025
Announcement of Results in the GATE Online Application Processing System (GOAPS)	Wednesday	March 19, 2025
Score Card available for free download	Friday to Saturday	March 28, 2025 to May 31, 2025
Score Card available for download by paying a fee of Rs. 500 per test paper	Sunday to Wednesday	June 1, 2025 to December 31, 2025

Note 2.1: The above mentioned dates are subject to change due to unforeseen/unavoidable reasons. [illegible] https://gate2025.iitr.ac.in

- Candidates have to register and fill the application online via GOAPS website ONLY at GATE 2025 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 to any IIT/IISc or any of the zonal GATE offices.
- The application fee must be paid online only through net banking, credit card, debit card, UPI, etc. If a candidate wishes to appear for TWO test papers, the fee to be paid by the candidate will be TWICE of that mentioned for a single paper.
- The Admit Cards for GATE 2025 would be available for download on the GATE 2025 website 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 paper(s) or Date/Time specified in the Admit Card will be entertained. Similarly, this being an Examination with online (computer based) mode, candidates needing non-standard or specific facility for the examination may not be entertained beyond the standard facilities. Hence, candidates are requested to adhere to the facilities that are provided within the scope and resources of GATE Examination Body.
- Physical calculators, mobile phones or any other electronic/communication devices, log tables, charts, books, handbooks, notes, wristwatches, any such items are STRICTLY PROHIBITED. Necessary facilities and conditions on possessing these items (if any) will be prescribed.
- The photographs of the (qualified) candidates can be captured during the GATE 2025 exam.
- In all matters concerning GATE 2025, the decision of the GATE 2025 Committee will be final and binding on all the applicants.
- Although GATE 2025 will be held at different test centres across the country, the Indian Institute of Technology Roorkee, being the Organizing Institute, bears the overall responsibility of conducting GATE 2025. In case of any dispute or litigation arising with respect to GATE 2025, it is hereby made abundantly clear that the High Court of Uttarakhand at Nainital, Uttarakhand alone will have the exclusive jurisdiction to entertain and settle them.
- For candidates appearing for the Geology and Geophysics (GG) and Humanities and Social Sciences (XH) papers, separate score and ranking will be provided based on their selection of sections.
- For candidates appearing for Architecture and Planning (AR) and Geomatics Engineering (GE) papers, separate score and ranking will be provided based on their selection of sections.

4. Pre-Examination Related Information

4.1 Eligibility for GATE 2025

Before filling the application, candidates must ensure that they meet the educational eligibility criteria of GATE 2025 exam.

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/ Humanities is eligible for appearing in the GATE 2025 exam.

Disclaimer:

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 makes all aspirants eligible for Public Sector Undertaking (PSU) job, but it depends on the recruitment procedure of the concerned PSU. GATE Committee does NOT assume any responsibility for admission/ scholarship/ job.

Some of the Professional Societies/Institutions, which conduct examinations 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) (IIChE)
- The Indian Institute of Metals (IIM)
- The Indian Institute of Industrial Engineers (IIIE)

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

Note 4.1: [illegible]

Candidates who 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 / Architecture / Science / Commerce / Arts / Humanities. In case of eligibility criteria as given in Table 2, the candidates pursuing any higher degree or have already completed a degree higher than that mentioned in the Table 2, the candidates will be allowed to appear for GATE 2020 examination.

Note 4.2: If a candidate is pursuing any higher degree or has already obtained a degree higher than that mentioned in the Table 2, the candidate will be allowed to appear for GATE 2020 examination.

Note 4.3: [illegible]

Table 3: Eligibility Criteria for GATE 2020

Qualifying Degree	Qualifying Degree/Examination (Descriptive)	Description of Eligible Candidates
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
B.Arch.	Bachelor's degree of Architecture (5 years course)/ Naval Architecture (4 years course)/ Planning (4 years course)	Currently in the 3rd year or higher or already completed
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
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
M.B.B.S./ B.D.S./ B.V.Sc.	Degree holders of M.B.B.S./ B.D.S./ B.V.Sc. 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
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
Int. M.E./ M.Tech. (Post-B.Sc.)	Post-B.Sc. Integrated Master's degree programs in Engineering/ Technology (4 years program)	Currently in the 1st/ 2nd/ 3rd/ 4th year or already completed
Int. M.E./ M.Tech./ M.Pharm. or Dual Degree (after Diploma or 10+2)	Integrated Master's degree program or Dual Degree program in Engineering/ Technology (5 years program)	Currently in the 3rd/ 4th/ 5th year or already completed
B.Sc./ B.A./ B.Com.	Bachelor's degree in any branch of Science/ Commerce/ Arts/ Humanities (3 years program)	Currently in the 3rd year or already completed
Int. M.Sc./ Int. B.S.-M.S.	Integrated M.Sc. or 5 years integrated B.S.-M.S. program	Currently in the 3rd year or higher or already completed
Professional Society Examinations (equivalent to B.E./ B.Tech./ B.Arch.)	B.E./ B.Tech./ B.Arch. equivalent examinations of Professional Societies, recognized by MHRD/ 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
B.Sc. Agriculture, Horticulture, Forestry	4 years program	Currently in the 3rd/ 4th year or already completed

4.2. GATE 2025 Test Papers

GATE 2025 will be conducted for 30 test papers (subjects). Table 4 shows the list of test papers and codes for GATE 2025. [illegible]

Table 4: List of GATE 2025 test papers and their corresponding codes

Test Paper	Code	Test Paper	Code
Aerospace Engineering	AE	Geology and Geophysics	GG**
Agricultural Engineering	AG	Instrumentation Engineering	IN
Architecture and Planning	AR	Mathematics	MA
Biomedical Engineering	BM	Mechanical Engineering	ME
Biotechnology	BT	Mining Engineering	MN
Civil Engineering	CE	Metallurgical Engineering	MT
Chemical Engineering	CH	Naval Architecture and Marine Engineering	NM
Computer Science and Information Technology	CS	Petroleum Engineering	PE
Chemistry	CY	Physics	PH
Data Science and Artificial Intelligence	DA	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***

*XE Paper Sections	Code
Engineering Mathematics (Compulsory)	A
Any TWO optional sections	
Fluid Mechanics	B
Materials Science	C
Solid Mechanics	D
Thermodynamics	E
Polymer Science and Engineering	F
Food Technology	G
Atmospheric and Oceanic Sciences	H

**XH Paper Sections	Code
Reasoning and Comprehension (Compulsory)	B1
Any ONE optional section	
Economics	C1
English	C2
Linguistics	C3
Philosophy	C4
Psychology	C5
Sociology	C6

***XL Paper Sections	Code
Chemistry (Compulsory)	P
Any TWO optional sections	
Biochemistry	Q
Botany	R
Microbiology	S
Zoology	T
Food Technology	U

AR Paper Sections	**GE Paper Sections	**GG Paper Sections
Part A (Compulsory)	Part A (Compulsory)	Part A (Compulsory)
Part B1 (Architecture)	Part B1 (Surveying and Mapping)	Part B1 (Geology)
Part B2 (Planning)	Part B2 (Image Processing and Analysis)	Part B2 (Geophysics)

*XE (Engineering Sciences), **XH (Humanities & Social Sciences), ***XL (Life Sciences), papers are of [illegible]

Table 6: Allowed film text paper combinations in GATE 2020

Core/Elective Subject Paper	Subject Papers Allowed in the Secondary Paper	Subject Paper	Subject Papers allowed in the Secondary Paper
AE	CE, ME, PE	EE	EP, CE, IN, MA, PE
AG	CY	EC	EE
AR	CE, PE	EP	EE, EC, IN, MA, PE
BT	CY, XL	ES	CE, CY, MA, XE
CE	AR, CY, XL	ME	AE, CE, IN, MA, PE, PI
CH	AR, CE, AE, EC, EP, EY, IN	MF	PE
CS	EC, EE, IN	MM	CE, PE
CY	CE, EC, EE, ME, PE, XE	PE	CE
EC	CE, CY, EE	PI	CE, CH, EC, EP, EE, IN
EE	CE, EC, EE, IN, MA, EP, PE	PY	AR, PE
EY	CE, CH, EE, IN, PE	ST	CE, CH, ME, PE
GE	CE, EC, IN, MA	XE	AE, CE, CH, EC, EE, IN, MA, ME, PE, PI
GG	CE, CH, EE	XL	CE
IN	CE		

Note: (a) Candidates opting to appear in XE-C core papers must choose any one of the papers and a secondary elective of paper, which can be chosen from the allowed combinations given in Table 6. (b) Non-Bachelor/Degree holder = The date may be removed at a later date if there are withdrawing candidates, or other cases. The fee and Date for the second paper will be refunded to the candidates. (c) Only GATE 2019 (or) 2020 candidates are allowed to apply for the use of interpolation and extrapolation facility. (d) Candidates who are not satisfied with the results may apply for revaluation of their answer script(s) within six months from the announcement of the results. Revaluation is permitted only for those candidates who have appeared in the relevant paper and have not been disqualified in that paper or in all papers. The revaluation fee is ₹1500 per paper. The answer script(s) is assumed to be correctly evaluated in the first evaluation if no claim for revaluation is received within six months from the announcement of the results.

4.3 Distribution of Marks

Total Marks: 100; Total Time: 3 hours

Each test paper is for a total of 100 marks. All test papers have a General Aptitude (GA) section for 15 marks. The remaining 85 marks cover the subject chosen by the candidate. Table 4 shows the distribution of marks in various test papers of GATE 2021.

Table 4: Distribution of marks in various test papers of GATE 2021

Paper Code	General Aptitude (GA) Marks	Subject Compulsory Section	Subject Optional Section(s)	Total Marks
AE, AG, BM, BT, CE, CH, CS, EC, EE, ES, IN, ME, MN, MT, PE, PI, TF (Subject marks in these papers include questions in Engineering Mathematics of 13 marks, which is paper-specific)	15	85	—	100
CY, EY, MA, PH, ST	15	85	—	100
AR: Part A is Common and Compulsory. Part B: 30 marks to be selected during the exam. B1 – Architecture, B2 – Planning	15	55	30	100
GE: Part A is Common and Compulsory. Part B: 30 marks to be selected during the exam. B1 – Surveying and Mapping, B2 – Image Processing and Analysis	15	55	30	100
GG: Part A is Common and Compulsory. Part B1 or B2 must be chosen at the time of application. B1 – Geology, B2 – Geophysics	15	25	60	100
XE: Section A (Engineering Mathematics) is Common and Compulsory. Applicants must select any TWO of the other sections during the exam	15	15	2x35	100
XH: Section B1 (Reasoning and Comprehension) is Common and Compulsory. Applicants must select any ONE of the other sections at the time of application	15	25	60	100
XL: Section P (Chemistry) is Common and Compulsory. Applicants must select any TWO of the other sections during the exam	15	25	2x30	100

PwD candidates with benchmark disability more than 40% are eligible for compensatory time of one hour. PwD candidates with less than 40% disability and having difficulty in writing are eligible for compensatory time subject to production of a certificate as stated in Appendix-I of the guidelines issued by the Ministry of Social Justice and Empowerment F. No. 29-6/2019-DD-III, dated 10th August 2020. See the section Appendix-A for this information/certificate.

4.4 GATE 2020 Examination Cities

Table 7 [illegible] GATE 2020 [illegible] Zonal GATE Offices.

Choice of Examination City: A candidate can choose THREE cities from the list of examination cities given in Table 7 [illegible] GATE 2020 [illegible]

[illegible]

4.5 Application Process

Application for GATE 2020 must be submitted ONLINE [illegible] [illegible] Candidates MUST enter the valid [illegible] Aadhaar [illegible] Candidates MUST [illegible] GATE 2020 [illegible]

[illegible] GATE [illegible]

Table 7: Tentative List of Zone-Wise Examination Cities

Zonal GATE Office	Examination Cities
Zone 1 IISc Bangalore Bengaluru – 560 012 Email: [illegible] Phone nos.: [illegible]	Andhra Pradesh: [illegible] Karnataka: [illegible] Kerala: [illegible] Telangana: [illegible] Andaman and Nicobar: Port Blair
Zone 3 IIT Bombay Powai, Mumbai – 400 076 Email: [illegible] Phone no.: [illegible]	Gujarat: [illegible] Maharashtra: [illegible] Goa: Goa
Zone 4 IIT Delhi Hauz Khas, New Delhi – 110016 Email: [illegible] Phone no.: [illegible]	Haryana: [illegible] Jammu and Kashmir: [illegible] Ladakh: Leh Madhya Pradesh: [illegible] New Delhi: New Delhi Rajasthan: [illegible] Uttar Pradesh: [illegible]

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[illegible]

4.3.1 GATE 2020 Application Fee

[illegible]

Table 4: Details of application fee for GATE 2020 (per test paper)

Category	Regular Period [illegible]	Extended Period [illegible]
Female/ SC/ ST/ PwD* candidates	[illegible]	[illegible]
All other candidates including foreign nationals	[illegible]	[illegible]

[illegible]

*PwD: [illegible]

4.3.2 GATE Online Application Processing [illegible]

[illegible]

- Apply for the examination.
- [illegible]
- Pay the application fee through any of the available online payment modes.
- [illegible]
- [illegible]
- [illegible]
- [illegible]

Registration: [illegible]

[illegible] mobile number. Give the personal mobile number and e-mail address, because most of the communication will be through e-mail and/or SMS.

[illegible]: Each registered candidate will be provided with an Enrollment ID. Upon registration, an e-mail containing the Enrollment ID will be sent to the candidate. This Enrollment ID will be the reference ID for all future communications with the organizing institute.

[illegible]: The candidate has to choose a password during Enrollment. The password must be remembered along with the Enrollment ID to login to the user 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. [illegible] Length of the password should be [illegible] characters. Keep your password information safe, secure and confidential.

4.4.2 Filling in GATE 2026 Application

After the registration, GATE 2026 application form must be filled in the [illegible] form.

Candidates must themselves fill the application through a [illegible]. The application is filled by someone else (friend, internet café owner, etc.) on behalf of the candidate, it is the responsibility of the candidate to ensure that the submitted data is correct.

[illegible]: The following items 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 at the examination hall for GATE 2026 examination at the centre. GATE 2026 scorecard will be issued as per the name entered in the application form.

[illegible]

• Address for Communication (including PIN code)

• Eligibility degree details

• Outside India exam centre (if applicable)

• Choice of GATE test papers

• Choice 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)

• [illegible]

(i) Application Filling: The GATE 2020 website allows you to enter the data, save and verify filled items, logout and resume filling the form in logged in option. The online application process is user friendly and user-friendly. Additional fields or information required in filling various fields in the application form will also be made available.

Before proceeding to payment, the candidate must carefully 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 4.6.5 for payment options.

(ii) 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 2020) examination and I, myself have filled up the 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 rules and procedures for GATE 2020 examination as detailed or prescribed in 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 later stage, my candidature for GATE 2020 examination will be cancelled. The cancellation of my candidature can happen either before, during or after the examination, including the time after generation of my GATE 2020 score card, if any.

I also understand that GATE is NOT an admission seeking examination, and qualifying in GATE examination does NOT guarantee admission/scholarship/job. GATE 2020 Committee is NOT liable for any legal obligations related to admission/job/scholarship.

I am aware that the data provided by me during the application process as well as my GATE results may be shared for admission/recruitment purposes.

I shall be liable for legal action for providing any kind of false information. GATE 2020 Committee's decision will be final and legally binding on me.

(iii) Problems in Logging in to GOAPS: In case of forgotten user ID or password, follow the instructions on the GATE 2020 website to retrieve them.

4.6.4 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, Voter ID, Government issued ID, Passport, PAN Card, Voter ID or Driving License. On the examination day, the candidate must bring the original ID used along with the GATE 2020 Admit Card. Candidates will NOT be permitted to take the examination, in case the same valid and the same valid original photo identification document are NOT presented during the examination.

4.6.5 PwD Candidates and Scribe related Guidelines

GATE 2020 will follow the government guidelines for conducting examination for persons with specified disabilities (Appendix A).

Refer: http://gate.iitr.ac.in/documents/PWD_and_Scribe_Guidelines.pdf

1. Person with Benchmark Disability (PwBD) Diploma candidates have the option of availing scribe assistance during the GATE 2020 examination. The candidate must exercise the option at the time of filling the application. PwD and Diploma candidates can either provide their own scribe or request the GATE 2020 Organizing Institute to provide for a person of scribe.
• The assistance that the scribe provides to the candidate is limited to reading the instructions and "fair" visual displayed on the computer screen and/or writing as instructed by the candidate.
• The scribe shall not possess the educational qualification that is the requirement of the candidate.

Compensatory Time for PwD Candidates

The Gazette Notification of the candidates who are appearing in GATE 2020 Examination, as per the Government of India (GoI) guidelines, provides the candidates have opted to bring their own scribe. Then the qualification of the scribe should be one step below the qualification of the candidate taking the examination.

• PwD Diploma candidates have opted for their own scribe but may also opt to bring their own scribe (not from the GATE 2020 list) provided it is arranged by them.
• NO honorarium will be paid to the scribe arranged by the PwD Diploma candidates.

Scribe Arranged by GATE

• GATE facilities will be used for those PwD Diploma candidates who have applied for GATE Scribe.
• 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 (10th) or above.
• If there are 7 candidates in the respective cities, then it is ensured that a panel of 7 (10%) scribes is available at the exam centre so that every candidate can have an alternative scribe to choose for the exercise. A PwD / Diploma candidate having disabilities will be provided with PwD scribes from the panel. The candidate has to choose one from these 7 scribes. Candidates who have brought their own scribe, if they have already applied for scribe to be arranged by GATE.

Compensatory Time for PwD Candidates

PwD candidates, if required, can avail the Scribe facility. Based on the Gazette Notification, PwD candidates have the option of availing Scribe facility. In order to avail the facility, candidates have to indicate their choice in the application form. Candidates who have availed the Scribe facility in the GATE 2019 examination will be given an option to choose the same or a new Scribe. If a candidate who has availed the Scribe facility in the GATE 2019 examination does not indicate his/her choice in the application form, the Scribe facility will not be provided in GATE 2020. Candidates availing the Scribe facility will be provided compensatory time of 20 minutes per hour of examination (i.e. 1 hour 40 minutes for the 5 hour paper and 1 hour 20 minutes for the 4 hour paper).

PwD candidates who do not wish to avail the Scribe facility may also opt for compensatory time. Candidates who have availed the Scribe facility in the GATE 2019 examination will be given an option to choose the same or a new Scribe. If a candidate who has availed the Scribe facility in the GATE 2019 examination does not indicate his/her choice in the application form, the Scribe facility will not be provided in GATE 2020. Candidates availing the Scribe facility will be provided compensatory time of 20 minutes per hour of examination (i.e. 1 hour 40 minutes for the 5 hour paper and 1 hour 20 minutes for the 4 hour paper).

PwD Candidates who wish to avail the Scribe facility should inform the examination organizing institute in advance and submit a request letter along with the self-declaration form.

Compensatory Time

Candidates with Benchmark Disabilities are entitled for compensatory time of 20 minutes per hour of examination (i.e. 1 hour 40 minutes for the 5 hour paper and 1 hour 20 minutes for the 4 hour paper). PwD / Diploma candidates with Benchmark Disabilities will be provided compensatory time of 20 minutes per hour of examination (i.e. 1 hour 40 minutes for the 5 hour paper and 1 hour 20 minutes for the 4 hour paper). Candidates who have availed the Scribe facility in the GATE 2019 examination will be given an option to choose the same or a new Scribe. If a candidate who has availed the Scribe facility in the GATE 2019 examination does not indicate his/her choice in the application form, the Scribe facility will not be provided in GATE 2020. Candidates availing the Scribe facility will be provided compensatory time of 20 minutes per hour of examination (i.e. 1 hour 40 minutes for the 5 hour paper and 1 hour 20 minutes for the 4 hour paper).

4.6.4 Supporting Documents

i. Photo ID

Candidates MUST upload pdf file of any one of the following valid photo identity (ID): Aadhaar-UID (preferably), Aadhaar Virtual ID, Government issued ID, 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 acceptable identification document.

The candidates who do not possess any of these identity cards, may please obtain any one of these before making the application. Candidate MUST produce the SAME original valid photo ID card together with the GATE 2020 Admit Card during the examination for verification purposes. In absence of the SAME original valid photo ID proof, candidate will NOT be allowed to appear for GATE 2020 examination.

ii. Category (SC/ST) Certificate

Candidates who belong to SC or ST category have to upload a valid documentary proof for availing concession in application fee. Certificate issued ONLY by the authorized officials at the tahsildar/ or Appendix 3, List of Authorities Empowered to issue SC/ST Certificate). Necessary legal actions will be initiated for any wrong/false/fraud information. The same document is required to be submitted at the admitting institute, 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 declarations 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 in an examination, to write/type/dictate or speak, may request during the application time for availing the services of a scribe. Kindly refer to Section 4.8 for scribe related guidelines.

iv. Certificate of Dyslexia

To avail the services of a scribe, the dyslexic candidates should attach a proper dyslexia certificate issued by any authorized Dyslexia Association as in Appendix 4, (or Authorized Professionals) of their Certificate of Dyslexia. Kindly refer to Section 4.8 for scribe related guidelines. The same document is required to be submitted to the admitting institution at the time of admission. The onus of verifying dyslexia certificate lies with the admitting institute. The GATE Committee will NOT be responsible for any incorrect declaration of the dyslexic status of candidates.

4.6.1 Photograph and Signature Requirements

ICAO Guide application requires that candidate's photograph and signature are in the specified environment as per ICAO guidelines. Uploaded photograph and signature that does not meet the specifications mentioned will result in the disqualification of the application and forfeiture of the application fee.

a. Photograph Requirements

- Upload a good quality, colour photograph. The applicant can click a new photograph with the help of the candidate covering 80-90% of the photograph.
- The background of the photograph must be white and not contain any other colours or patterns.
- The photograph must show the entire face clear looking to camera. The camera must show the forehead, eyes, nose, and chin. The face in the photograph must not be covered with objects such as caps/hats, sunglasses, coloured glasses, etc. However, spectacles (or clear prescription spectacles) are allowed. If the candidate normally wears spectacles, a photograph with glasses (the glasses is NOT compulsory). If the glare cannot be avoided, the spectacles MUST be removed.
- Upload the image of your photo in JPEG / JPG format and size with a minimum required value of 3.5KB, maximum should not exceed 4.5KB. After cropping, the image size, face must cover 50-70% of the image.
- The minimum pixel resolution is 480 x 640 pixels and the maximum resolution is 600 x 240 pixels. The face area must be minimum of 8 KB and a maximum of 11 KB.
The face must be visible clearly and should not be any shadow.
- Face in the photo must NOT be covered with any facial shade (visual assistance with spectacles/ Sunglasses, Glass, Hats, Coloured glasses, etc. are NOT allowed. Also, NO objects/items in the background are allowed.
- The entire face area of the face must not be covered by hair of the head, any cloth or any shadow. Head covering is not permitted except for religious reasons, but the face (top of chin to bottom of ear to the top of head) and both sides of the face must be clearly visible.
- The applicant with a corrupted image or other errors could lead to rejection of your DATE application without any refund of the application fee.
- Take a Selfie in the presence of a recognized gazetted officer/Bank Manager/Post Master/Head of Institution.
- The number for cropping the photo image are given in Figure 4.1

a. Face should be in 40, 50, 60, 70, 80 and 90 pts.
b. Top distance should be start with 40 pts upward.
c. Eye and face should be middle of the camera.

Figure 4.1 Displaying the cropping guideline of the image to be uploaded

Table 5. Samples of acceptable and unacceptable photographs

4. Signature specification

Upload the image of your total signature in JPEG / JPG format of size with aspect ratio (height : width = 1 : [illegible]), where, value of [illegible] can be between [illegible] to [illegible]. After cropping to the mentioned size, area of signature must cover [illegible] of the image.

- Signature of the candidate must be in black or dark blue colour ink pen.
- File size MUST be within [illegible] KB minimum to [illegible] KB maximum.
- The signature by any other person or 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 [illegible] 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 must be [illegible] in pixels.
- The minimum image size for the signature should be [illegible] 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 would be disqualified.

Annexure III: Examples of acceptable and unacceptable signatures

Acceptable Signatures

Unacceptable Signatures

4.2.2 Application Fee Payment Options

Details of the application fee are given in Table 4. The GATE 2024 application portal directly redirects to the payment options which provides options for fee payment via Net banking, debit card, credit card, UPI. The fee amount will be shown to the candidate, and they will have to confirm and pay. Once the payment is successful, the candidate will be redirected to the GATE 2024 application portal, from where they will need to submit the application form for documents.

If the candidate has a difficulty like payment due to poor internet connection or server failure problems, the candidate 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 wait for the GATE 2024 application portal after some time and check the status of the payment.

If the payment was received by GATE 2024, the candidate will have pending the application form. If the payment is not received by GATE 2024, a final payment must be initiated. In case the fee amount has been debited/deducted from your bank account, but an acknowledgement for the payment has not been received from GATE 2024, then the money will be credited back to your bank account within a few days.

In case of multiple payments made due to technical glitches, it will result in one application. The extra fee paid will be refunded/credited to the same bank account within 10 days. In case a payment confirmation has not been successful, the candidate can initiate a new payment without waiting for the refund of the earlier payment, or complete the application submission process within the deadline. Candidates are advised to apply and complete the payment well ahead of the closing date to avoid problems due to last minute rush.

Before submitting GATE 2024 Application Form, the candidate MUST ensure that all the details and all the necessary supporting documents are filled correctly and there is NO ERROR in the process. An application once submitted CANNOT be changed/ modified. In a situation the candidate MUST verify that he/she has filled correct and valid the following information, whether or not applicable:

- Personal information (name, date of birth, parental details, mother's name, category, gender, nationality, mobile number (should be of the candidate), permanent address, mobile number)
- Address for Communication (including PIN code).
- Eligibility degree details (Valid for Registration No./College address, PIN code of college).
- Email id (Only email id of candidate should be mentioned in the documents specified).
- Correct entry (image) of signature corresponding to the required 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) or medical assessment or examination fee as claimed.

Note: It is essential that the candidate fills in the details in GATE 2024 online application form carefully with ERROR. The application form is liable to be REJECTED if found to any error. GATE Committee (GC) responsible for the rejection of any application due to such errors.

4.3 Application Scrutiny and Rectifications

All the applications submitted for GATE 2024 examination will be scrutinized for the accuracy of the data, which includes scanned supporting documents, name, all the photographs and signature. If everything is found to be in order, the application will be completed. Otherwise, the defects in the application will be marked and informed to the candidates by email or SMS for rectification within a stipulated time frame. The status of an application will be updated after scrutiny by the concerned examining GATE office. The correct status of the candidature's examination will be shown against the login id in the GATE 2024 account.

Candidates should visit (only) the website of the organising institute and carefully follow the displayed deadlines. Candidates who successfully login to the Application Portal will check the current status of the online application form.

Note: In no circumstances, the options within the stipulated time can a candidate change/modify/edit the application or the "Payment of fee (wherever applicable)" and GAT Committee/Organising Institute will not be responsible in this regard.

4.7 Admit Card

Admit Card/Hall Ticket will be downloaded from the GATE 2025 website from 2nd January 2025. Admit Card/Hall Ticket will not be sent by post or even in the Email/Courier.

Candidates must bring a valid copy of the downloaded Admit Card/Hall Ticket to the Examination Hall along with one original photo identity document (ID). Candidates not bringing a valid ID will not be allowed to appear in the examination. Only the following IDs will be considered valid: Aadhaar Card, Aadhaar Enrolment ID Receipt, PAN card, Voter ID card, Driving License.

The Admit Card should have the candidate's photograph and signature clearly visible and legible. The photograph on the Admit Card must be the same as the one uploaded during the online application. The candidate must bring a hard copy of the Admit Card to the examination hall. Candidates must write the examination paper using a black ballpoint pen only. Admit Card/Hall Ticket will be issued only to those candidates who have successfully completed the online application process.

Candidates are advised to regularly check the GATE 2025 website for any updates.

5. GATE 2025 Examination Related Information

GATE 2025 examination will be conducted for 30 test papers as listed in Table 1. Candidates can appear for any one test paper mentioned in Table 1 of the GATE Exam. The examination for all the test papers will be conducted in Computer Based Test (CBT) mode in which the candidate will be shown the questions on a computer screen.

A Virtual Scientific Calculator will be available on the computer screen during the examination. Candidates are not allowed to use any other calculator during the examination. Possession and/or use of any other electronic gadgets such as mobile phone, Bluetooth devices or any such other communication devices are NOT allowed inside the examination hall. Candidates must NOT bring any books/ charts/ notes/ loose sheets/ papers/ pens or pencils/ pouches/ purses/ bags/ caps/ goggles/ wristwatches and candidates found in possession of such belongings will be disqualified regardless of whether they use them or not. GATE Centre and GAT Committee/Organising Institute will not be responsible for the safekeeping of any such belongings.

A rough sheet will be provided to the candidates for rough work. The candidates have to write their name and registration number on the rough sheet before they start using it. The candidates must return the rough sheet to the invigilator at the end of the examination. Candidates found tampering with the rough sheet after the examination will be disqualified.

Detailed syllabi of the papers (Appendix-1), previous years GATE question papers, and model examination tests along with virtual scientific calculator will be available on GATE 2025 website: https://gate2025.iitr.ac.in/

Note 1: Since GATE offers 30 papers, candidates are advised to carefully check the eligibility criteria for admission to various programmes in which they are interested. Candidates should not appear in a paper in which they are not eligible to seek admission. GAT Committee/Organising Institute will not be responsible for any candidature issues in the event of non-observance of this requirement. Any individual enquiries/clarifications regarding eligibility criteria for admission in the interested Post-graduate programmes should be addressed to the concerned Admitting Institutes.

3.1 Examination Duration

All test papers of the GATE 2025 examination will be of 3 hours duration (4 hours in case of candidates availing compensatory time), consisting of 65 questions for a total of 100 marks. After the examination duration has elapsed, the examination will terminate automatically.

Candidates will be given 10:00 hrs to enter the allotted seats at venues before the scheduled start of the examination. Candidates can login and start reading the instructions 30 minutes before the start of examination. A candidate will not be permitted to login after 30 minutes from the scheduled start of the examination. Candidates will NOT be permitted to leave the examination hall before the scheduled end of the examination.

3.2 GATE 2025 Question Papers

3.2.1 Types of Questions

GATE 2025 test papers can be from three categories: Multiple Choice Questions (MCQs), Multiple Select Questions (MSQs) and Numerical Answer Type (NAT).

(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 choices of four answers, out of which ONLY ONE choice is correct.

Legend for Marking for Wrong Answers: There will be negative marking for wrong answers in MCQ. 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:
What will be the value of engineering GATE 2025 examination?
(A) 0 (B) 1/2 (C) 1 (D) 2

Here, correct answer is (A) only. Question will get full marks only if the answer is correct. The candidate will be given ONLINE facility of choosing any option from the answers.

(ii) Multiple Select Questions (MSQ) carry 1 or 2 marks each. Each MSQ will have a total of four answers, out of which ONE or TWO or THREE or FOUR answers is/are correct.

Note: There is NO negative marking for wrong answers in MSQ. However, there will be NO partial marks for answering any MSQ. The candidate will be given ONLINE facility of choosing any number of options from the answers.

Example of MSQ:
Which of the following is/are prime number?
(A) 2 (B) 3 (C) 4 (D) 5

Here, the correct answer is the combination of (A), (B) and (D). Candidate will get full marks if and only if the combination is matched. There are NO partial marks in this type of question. The candidate will NOT get any marks for choosing fewer options than the correct number of options in the answer.

(iii) Numerical Answer Type (NAT) carry either 1 or 2 marks each. For NAT questions, the answer is a signed real number which must be entered by the candidate using the virtual numerical keypad on the monitor. Decimal point and negative sign will be available. 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 place) or 10.01 (two decimal places) or -10.001 (three decimal places). The exact value of the NAT numerical answer will indicate the number of decimal places that must be provided in the

answers. Candidates are required to round up if any at the end of the calculation and not at intermediate stages of the calculation.

Example: There are 60 regular meetings in a session of a SAT examination. How many SAT examinations were held in SAT sessions

Answer: 60/12 = 5 (the one dimension of a comprehensive format opening commenced by UK. the change in opening all these on for a _____ percent to five diagonal classes)

3.2.2 Marks distribution

There is a passage from the section containing a total of 60 marks, out of which 40 questions carrying a total of 10 marks will be on Reading Comprehension (RC), which is intended to test generally language and analytical skills.

In that section, MC, AC, BM, BT, BS, CH, EE, EE, BC, EL, EC, IN, MC, MN, VT, HH, RE, PI and TT, the Data Interpretation section will carry 10 marks and the remaining 30 marks are shared in the subject component, as of which Engineering Mathematics will carry 15 marks.

CE has a common and a compulsory section namely, ME4- Engineering Mathematics, which carries 15 marks.

In the sections of AT, CH, EC, BT, BS, EE, PM, BT, CH and CL, the General Aptitude section carries 10 marks and the remaining 55 marks are decided by the subject concerned.

3.2.3 Design of questions

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

(i) Recall: These are based on facts, principles, formulas or laws in the discipline of the paper. The candidates are expected to be able to obtain the answer either from their knowledge of the subject or extract it from a standard formula. Some questions may require the candidate to perform simple calculations.

Example:
Q. Choose the wrong statement from the following
(A) In fluid flow, Euler number is the ratio of pressure drop to inertial force
(B) In fluid flow, Froude number is the ratio of inertial force to gravity force
(C) In fluid flow, Reynolds number is the ratio of inertial force to viscous force
(D) In fluid flow, Weber number is the ratio of inertial force to surface tension force

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

Example:
Q. A 100 g mass requires a force of 1 N to move it.
(A) the mass is accelerating at 1 m/s² (B) the mass is in equilibrium (C) the mass is at rest
(D) none of the above (Correct Answer: (B) as the mass is in equilibrium)

(iii) Application: In these questions, the candidates are required to apply their knowledge of the subject to analyse and solve by logical reasoning.

Example:
Q. The resistor in the circuit shown in the figure has a resistance of 10 Ω. The heat generated in the resistor is 10 J. The heat generated in the resistor is
(A) 10 J (B) 20 J (C) 30 J (D) 40 J

The above questions may be a mix of single statement Assertion/Reason type questions, combination of factor sentence type questions or Matching type questions.

Data Analysis and Sufficiency: In these questions, the data, diagrams, images, etc. will be provided to the candidates, they require analytical skills in answering a question. A Statistics question might require the candidates to compare two or more pieces of information. Questions in this category could, for example, require the candidates being able to recognise unstated assumptions, or assessing useful information from irrelevant information. The questions may be in the form of a single statement, statement followed by data based questions, combination of questions or match the given items etc.

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 (subtotal 5 marks) and 5 questions carrying 2 marks each (subtotal 10 marks).

5.3.2 Question Papers other than AR, CE, ES, GE, PH and XE

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

5.3.3 Architecture and Planning (AR) Test Paper

Apart from the General Aptitude (GA) section, the question paper consists of two parts: Part A (30 marks) and Part B (30 marks). Part A is compulsory for all the candidates. Part B contains two parts: Part B1: Architecture (Core) 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 25 questions carrying a total of 25 marks: 10 questions carrying 1 mark each (subtotal 10 marks) and 15 questions carrying 2 marks each (subtotal 30 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 10 questions carrying a total of 30 marks: 7 questions carrying 1 mark each (subtotal 7 marks) and the 3 questions carrying 2 marks each (subtotal 16 marks). Some are MCQ type questions, while the remaining may be MSQ and/or NAT questions.

5.3.4 Geomatics Engineering (GE) Test Paper

Apart from the General Aptitude (GA) section, the question paper consists of two parts: Part A (30 marks) and Part B (70 marks). Part A: Engineering Mathematics and Basic Geomatics is compulsory for all the candidates. Part B contains two sections: Section I: Surveying and Geodesy and Section II: Image Processing and Analysis. 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 25 questions carrying a total of 30 marks: 10 questions carrying 1 mark each (subtotal 10 marks) and 15 questions carrying 2 marks each (subtotal 30 marks). Some are MCQ type questions, while the remaining may be MSQ and/or NAT questions. Either section of Part B (Section I (Surveying and Geodesy) or Section II (Image Processing and Analysis)) consists of 18 questions carrying a total of 70 marks: 6 questions carrying 1 mark each (subtotal 6 marks) and 12 questions carrying 4 marks each (subtotal 64 marks). Some are MCQ type questions, while the remaining may be MSQ and/or NAT questions.

5.3.5 Geology and Geophysics (GG) Test 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 I (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 25 questions carrying a total of 35 marks: 15 questions carrying 1 mark each (sub-total 15 marks) and 10 questions carrying 2 marks each (sub-total 20 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 30 questions carrying a total of 50 marks: 10 questions carrying 1 mark each (sub-total 10 marks) and 20 questions carrying 2 marks each (sub-total 40 marks). Some are MCQ type questions, while the remaining may be MSQ and/or NAT questions.

8.3.6 Engineering Sciences (XE) Test Papers

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

• General Aptitude (GA) 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. A candidate wishing to change midway of the examination must first deselect one of the previously chosen optional sections (B through H). The system will clear the answers, but there will be a message warning the candidate that the answers to the section being deselected will be deleted. Only after the candidate confirms will the answers be deleted and the section deselected.

8.3.7 Humanities and Social Sciences (XH) Test Papers

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

• General Aptitude (GA) carrying a total of 15 marks.

• Section B1 – Reasoning and Comprehension (Compulsory):

This section contains 15 questions carrying a total of 25 marks: 5 questions carrying 1 mark each (sub-total 5 marks), and 10 questions carrying 2 marks each (sub-total 20 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 choice of ONE 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 40 questions carrying a total of 60 marks: 20 questions carrying 1 mark each (sub-total 20 marks) and 20 questions carrying 2 marks each (sub-total 40 marks). Some are MCQ type questions, while the remaining may be MSQ and/or NAT questions.

5.2.2 Life Sciences (XL) Test Papers

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

- General Aptitude (GA) carrying a total of 15 marks.
- Section P – Chemistry (Compulsory): This section contains 17 questions carrying a total of 28 marks. 8 questions carry 1 mark each (8 marks in total) and 9 questions carry 2 marks each (total 18 marks). There are MCQ type questions with the correct answer to MCQ and to NAT questions.
- Any two of Sections Q, R and S: The choice of two sections from Q, R, S is to be made during the examination after viewing the questions. Each MCQ type optional section can be answered at a time. A candidate will get a chance at the end of the examination to modify/change/alter/edit/mark/unmark any of the responses in the two chosen optional sections (Q through S). This step will close the answers but there will be a message warning the candidate that the answers of the sections being unattempted will be deleted.

6. Post-Examination Related Information

Post examination events are as follows:

i) After the GATE 2020 examination, candidates' responses will be available in their account at GAPS 2020 website, which can be downloaded.
ii) Answer keys for various GATE 2020 test papers will be displayed in GAPS 2020 website.
iii) Candidates may submit their challenges on the answer keys provided for a very nominal fee per test paper as payment.
iv) Evaluation of examination test papers will be finished and GATE 2020 results (scores) will be announced.
v) Qualified candidates can download Score Card from their GAPS 2020 accounts.

6.1 GATE Score

After the evaluation of the answers, the actual raw marks obtained by a candidate will be converted to normalized GATE Marks. As the GATE papers are generally not the same, the marks obtained by the candidates in different papers will be converted to normalized marks for that particular subject. Thus, raw marks for single session test papers or normalized marks for multi-session test papers will be used for computing the GATE Score. Based on the resulting marks,

6.1.1 Calculation of Normalized Marks for Multi-Session Papers

In GATE 2020 examination, some test papers may be conducted in multi-sessions. For each test session, a suitable normalization is applied to take into account any variation in the difficulty level of the question sets across sessions. The normalization is done based on the fundamental assumption that the candidate distribution in different sessions is the same across all the sessions. This assumption is justified since the number of candidates appearing in multi-session test papers in GATE 2020 will be quite large and the procedure for allocation of session to candidates is random. Further, it is also ensured that for the same multi-session test paper, the number of candidates across each session for the same order of magnitude.

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

The normalized mark for the i^{th} candidate in the m^{th} session, denoted by $\hat{M}_{im}$, can be computed as

$$\hat{M}_{im} = \frac{\sigma_g^*}{\sigma_m} \left(M_{im} - \mu_m\right) + \mu_g^*$$

where,

M_{im} is the actual mark obtained by the i^{th} candidate in the m^{th} session.

μ_g^* is the average marks of merged 31 as of the candidates considering all sessions.

σ_g^* is the scale of mark post standard deviation scores of the candidates in the exam considering all sessions.

μ_m is the mean scores of the top 0.1% of the candidates in the m^{th} session and

σ_m is the scale of the scores in said session considered to be of the m^{th} session.

9.1.2. Calculation of GATE Score for All Test Papers

For a candidate who has scored any raw marks except marks as Generally the candidate will be awarded the GATE 2024 Score. For appearing in multiple sessions, normalized marks will be calculated corresponding to the raw marks obtained by a candidate as mentioned in Section 9.1.1 and the GATE 2024 Score will be calculated based on the normalized marks.

The GATE 2024 score will be computed using the formula given below:

$$\text{GATE Score} = S_q + (S_t - S_q)\frac{\hat{M} - \hat{M}_q}{\hat{M}_t - \hat{M}_q}$$

where,

$\hat{M}$ is the marks obtained by the candidate in the session (or single session in case of candidates appearing in more than one session).

$\hat{M}_q$ is the qualifying mark for the General category candidates in the session.

$\hat{M}_t$ is the mean of marks of top 0.1% or top 10 candidates (whichever is larger) of the candidates who appeared in the session (or in case of multiple sessions, as in the case of candidates who appeared in more than one session, then the mean of such multiple sessions considering all candidates).

S_q = 350 is the score assigned to $\hat{M}_q$ and

S_t = 900 is the score assigned to $\hat{M}_t$.

If GATE 2024, the qualifying mark ($\hat{M}_q$) for the general category candidates in each session will be [illegible] or μ + 1.0 σ, whichever is larger, where μ is the mean and σ is the standard deviation of qualified candidates who appeared in the session.

8.2. GATE 2025 Results

GATE 2025 results will be announced on the GATE 2025 Website. GATE 2025 score is valid for THREE YEARS from the date of announcement of the results. No information on the GATE 2025 score will be available after this period.

8.3. GATE 2025 Scorecard

After the announcement of results, GATE 2025 Scorecard of the qualified candidate can be downloaded free of cost between 28th March 2025 to 31st May 2025 from the GATE 2025 website. It is highly recommended that a soft copy of the scorecard is safely stored by the candidate for all the future uses.

In case, GATE qualified candidates require the softcopy of the GATE Scorecard after 31st May 2025 and till 31st December 2025, they MUST pay a fee of ₹ 500 (Rupees five hundred only) per test paper for obtaining the score. From 1st January 2026 onwards, NO scorecard will be issued for GATE 2025 qualified candidates.

There are NO provisions for the issue of hard copies of the GATE Scorecards.

Appendix A: Certificate issuing authorities

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 Tehsildar
- Sub-Divisional Officer of the area where the Candidate and/or his/her family normally resides
- Administrator/ Secretary to Administrator/ Development Officer (Lakshadweep Islands). Certificate issued by any other officer will NOT be accepted.

Person with Disability (PwD) Category

[illegible]

Authorities Empowered to Issue Certificate of Dyslexia

[illegible]

- Dyslexia Trust of Kolkata, [illegible], Kolkata – [illegible]
- Dyslexia Association of Andhra Pradesh [illegible]
- Madras Dyslexia Association, [illegible], Chennai [illegible]
- Maharashtra Dyslexia Association, [illegible]
- The Dyslexia Association of India, [illegible], NOIDA [illegible]

PwD candidates may [illegible]

Guidelines for Conducting Examination for PwD Candidates

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

4. [illegible]

5. [illegible]

Sd/-

[illegible]

[illegible]

To

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]

4. [illegible]

[illegible]

[illegible]

Appendix I

[illegible]

[illegible]

1. [illegible]

2. [illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]				
[illegible]				

[illegible]

Place:

Date:

[illegible]

Appendix-II

Letter of Undertaking to be given by the person who has specified travelling / records outside the jurisdiction of Directorate of Agriculture (Plant) Goa, 2009 in the case request under the Schedule of Services (A) of the Act, for provision hearing from their office (location) and hearing date/time in writing.

I, _____, s/o / w/o/d/o/ Mr. _____ (Name of candidate/candidate) possessing the No. _____ (owner of the machine/crop) bearing Roll No. _____ at _____ (place of the centre) in the District _____ (Name of the State), Mr. _____ (educational qualification) in _____.

2. I, the above-mentioned _____ (Name of the candidate) will provide the services of works for the undersigned the hearing can also be conducted remotely.

3. I, the [illegible] undertake that [illegible] in _____ the case undersigned, it is found not the candidate is not in fulfilment by the undersigned and is required by practitioner. I shall forfeit any rights in the post or candidature/training/degree and decision making [illegible].

(Signature of the candidate)

(Name and Designation of the [illegible] candidate or relative)

Place:

Date:

Appendix B: Code of Conduct for GATE 2025 Examination

Candidates appearing for GATE 2025 must strictly comply with the following code of conduct:

- Candidates appearing for GATE 2025 examination must carry Admit Card and ORIGINAL valid photo identity proof (used at the time of registration) inside the examination hall.
- Scribble pad will be provided to the candidate for rough work [illegible]. Candidates MUST write their name and registration number on the scribble pad before they start using it. The candidate can request ONLY one scribble pad at any point of time. Before issuing the next scribble pad, the previous scribble pad MUST be returned to the invigilator. Any scribble pad in the possession of the candidate MUST be returned to the invigilator after the end of the examination.
- Carrying mobile phones and/or any electronic gadgets / devices of any form and size inside the examination hall is strictly PROHIBITED.
- Carrying any electronic communication devices, wallets, papers, cheat sheets, pen/pencil, and printed or handwritten manual, stationery, inside the examination hall is strictly PROHIBITED.
- All means and modes 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 is detected during the examination, it will automatically lead to DISQUALIFICATION of candidature. Results will NOT be declared for such candidates.
- The GATE Examination Body comprising Organizing Institute and Zonal Institutes will not take any responsibility regarding safety and security of mobile phones/ electronic devices/ any kind of valuables/ belongings of candidates.
- Candidates MUST not tamper with the computer and the relevant hardware provided in the examination hall. Candidates found tampering the computers will face DISQUALIFICATION [illegible]. In addition, appropriate legal action may be initiated against such candidates.

Note: Candidates involving unfair means and not complying with the code of conduct and rules of GATE 2025 [illegible] 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

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 the questions on Core Topics and the remaining 10% on Special Topics.

Section 1: Engineering Mathematics

Core Topics:

Linear Algebra: Vector algebra, Matrix algebra, systems of linear equations, rank of a matrix, eigen values and eigen vectors.

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; take-off and landing; steady climb and descent; absolute and service ceiling; range and endurance, load factor, turning flight, V-n diagram. Winds: head, tail and cross winds.

Static stability: Stability and control derivatives; longitudinal stick fixed and 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.

Special Topics: None

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-Joukowski 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 and 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.

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

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

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, Cayley-Hamilton theorem, Eigen values and Eigen vectors, 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 operator – 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 inverses; 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 2: 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 tests; 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 3: 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 important 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; stream flow 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 – soil 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 inlet and chute spillways; earthen dams.

Watershed Management: Watershed characterization and land use capability classification; water harvesting in watersheds; 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 agricultural produce: Physical, thermal, frictional, rheological and electrical properties.

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

Size Reduction and Material Handling: Fundamentals and energy requirement in size reduction of agricultural materials; 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 Agricultural Produce: Processing of seeds, spices, fruits and vegetables; value addition of agricultural produce.

Storage Systems: Controlled and modified atmosphere storage; perishable food storage, godowns, bins and grain silos; packaging materials 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 Architecture and 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 eminent planners and designers; Survey methods; 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

Fire fighting 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-transit 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; Sustainable 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 environment; 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 Participation 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, Municipal/Panchayati Raj 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 analysis 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, 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 variation of parameters, 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 bio potentials 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; Elastic 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; Biomaterials 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, fresh water 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 and 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, kLa 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/Protein sequencing; Southern/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; Friction 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 2: 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 3: 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

[illegible] industries [illegible], [illegible] PVC [illegible].

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, Mean value theorems, Integration.

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

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, pointers, structures, linked lists, stacks, queues, trees, binary search trees, heaps, hash tables.

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 pushdown automata. Regular and context-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 analysis: constant propagation, liveness analysis, common sub-expression elimination.

Section 7: 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 8: 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 9: Computer Networks

Concepts 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; molecular 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: micro canonical, canonical and grand canonical ensembles, Boltzmann distribution, partition functions and thermodynamic properties.

Kinetics: 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. Diels- cycloaddn – 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 reactions.

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

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

Spectroscopic Techniques in Organic Chemistry: General applications of various chromatographic techniques such as HPLC, column, HPLC and GC. Applications of UV-visible, IR, NMR and Mass spectrometry in the structural determination of organic molecules.

DA Data Science and Artificial Intelligence

Probability and Statistics: Counting (permutation and combinations), probability axioms, Sample space, events, independent events, mutually exclusive events, marginal, conditional and joint probability, Bayes Theorem, conditional expectation and variance, mean, median, mode and standard deviation, correlation, and covariance, random variables, discrete random variables and probability mass functions, uniform, Bernoulli, binomial distribution, Continuous random variables and probability distribution function, uniform, exponential, Poisson, normal, standard normal, t-distribution, chi-squared distributions, cumulative distribution function, Conditional PDF, Central limit theorem, confidence interval, z-test, t-test, chi-squared test.

Linear Algebra: Vector space, subspaces, linear dependence and independence of vectors, matrices, projection matrix, orthogonal matrix, idempotent matrix, partition matrix and their properties, quadratic forms, systems of linear equations and solutions; Gaussian elimination, eigenvalues and eigenvectors, determinant, rank, nullity, projections, LU decomposition, singular value decomposition.

Calculus and Optimization: Functions of a single variable, limit, continuity and differentiability, Taylor series, maxima and minima, optimization involving a single variable.

Programming, Data Structures and Algorithms: Programming in Python, basic data structures: stacks, queues, linked lists, trees, hash tables; Search algorithms: linear search and binary search, basic sorting algorithms: selection sort, bubble sort and insertion sort; divide and conquer: mergesort, quicksort; introduction to graph theory; basic graph algorithms: traversals and shortest path.

Database Management and Warehousing: ER-model, relational model: relational algebra, tuple calculus, SQL, integrity constraints, normal form, File organization, indexing, data types, data transformation such as normalization, discretization, sampling, compression; data warehouse modelling: schema for multidimensional data models, concept hierarchies, measures: categorization and computations.

Machine Learning: (i) Supervised Learning: regression and classification problems, simple linear regression, multiple linear regression, ridge regression, logistic regression, k-nearest neighbour, naive Bayes classifier, linear discriminant analysis, support vector machine, decision trees, bias-variance trade-off, cross-validation methods such as leave-one-out (LOO) cross-validation, k-folds cross-validation, multi-layer perceptron, feed-forward neural network; (ii) Unsupervised Learning: clustering algorithms, k-means/k-medoid, hierarchical clustering, top-down, bottom-up: single-linkage, multiple-linkage, dimensionality reduction, principal component analysis.

AI: Search: informed, uninformed, adversarial; logic, propositional, predicate; reasoning under uncertainty topics — conditional independence representation, exact inference through variable elimination, and approximate inference through sampling.

EC Electronics and Communication Engineering

Section 1: Engineering Mathematics

Linear Algebra: Vector space, basis, linear dependence and independence, matrix algebra, eigen values and eigen vectors, 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 Stoke's 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 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, photodiode 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.

Operational Amplifiers: amplifiers, summers, differentiators, integrators, active filters, Schmitt triggers and oscillators.

Section 5: Digital Circuits

Number Representations: Binary, integer and floating point numbers, Combinational circuits: Boolean algebra, minimization of functions using Boolean identities and Karnaugh maps, 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 models 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, Eigen values, Eigen vectors.

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 to 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, Butterworth, 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, Taylor series expansion, Definite and indefinite integrals, Application of definite integrals to obtain area and volume, Partial derivatives.

Differential Equations: Linear and nonlinear 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 errors, precision, accuracy and significant figures, Probability concepts, Conditional probability, Bayes' theorem, Risk and hazards, Probability distributions, Correlation, Simple and multiple regression models, Hypothesis testing of one sample and two samples.

Section 2: Environmental Chemistry

Fundamentals of Environmental Chemistry: Chemical and biochemical changes, Chemical equilibrium, concentration and activity, Structure and chemistry of organic molecules, Reactivity of organics, Chemical equations, 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 transformation.

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 atmospheric smog and particulate pollution, Chemistry of ozone formation, Chemistry of stratosphere.

Section 3: Environmental Microbiology

Microbial and Biochemical Processes: Characteristics of microbial groups of microorganisms, Classification of microorganisms, Microbial diversity, Pathogenicity and saprophytic interactions, Role of microorganisms in wastewater treatment, Biomineralization and biogeochemical cycling.

Cell Chemistry and Cell Biology: Structure of proteins, nucleic acids (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

Fresh 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 relationships; Reservoir capacity; Reservoir and channel routing; Surface runoff models; Surface water management; Rain water harvesting and storage.

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

Environmental Hydraulics: Concepts of mechanics; Properties of fluids; Pressure measurement; Hydrostatic force on surfaces; Buoyancy and floatation; 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, rapidly varied flow, gradually varied flow; Design of lined and unlined channels.

Section 5: Water & Wastewater Treatment and Management

Water and wastewater quality parameters; Self-purification and thermal stratification in lakes; Streeter-Phelps - Oxygen sag curve.

Water treatment methods — screening, sedimentation (plain and with 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; stationary sources, area, transport, major air pollutants; Effects on health and environment of air pollutant gases and particulate matter; Air quality standards; Primary and secondary pollutants; Criteria pollutants; emission and ambient 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; Automobile emission control; fuel quality, diesel particulate filters, catalytic converters.

Air Quality Management: Point, line and area sources; Inversion; 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 three Rs); biological methods; energy recovery processes and landfilling.

Hazardous waste management: Characterization, generation, fate of chemicals 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 3: 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 4: 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 issues.

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); niche and habitat.

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: Coevolution (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 pattern; imprinting; learnt behavior; proximate and ultimate questions.

Sensory Ecology: Neuroethology; communication (chemical, acoustic and visual signalling); 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 Section: Engineering Mathematics and basic Geomatics

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

Remote Sensing: Basic concepts, 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, Uses, 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 Database (spatial and non-spatial), Spatial analysis – interpolation, Buffer, Overlay, Terrain Modelling and Network analysis.

Part B1: Surveying and Mapping

Maps: Importance of maps in engineering applications, Types of maps, Scale and uses, Plotting accuracy, Map sheet numbering, Coordinate systems- Cartesian and Geographical, map projections, introduction to UTM, Geoid, ellipsoid, WGS 84.

Land Surveying: Distance, angle, levelling methods, Compass, Theodolite and Total Station and their uses, Tacheometry, Trigonometric levelling, Traversing, Triangulation and Trilateration.

Photogrammetry: Types of photographs, Flying height and scale, Relief displacement, Stereoscopy, 3-D Model, height determination using Parallax bar, Digital Elevation Model (DEM), Orthophoto.

Part B2: Image Processing and Analysis

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

Digital Image Processing: Digital image characterization: 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: Filters and Spatial Filters.

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

Image Segmentation and Classification: Basic 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 B1: Geology

Geomorphology: Weathering 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 geochemistry; 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; provenance 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 fluids composition including fluids in metamorphism; thermobarometry and metamorphic P-T-t paths, and their tectonic significance.

Paleontology: 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, ostracods, conodonts, bryozoa); Vertebrates paleontology (Siwalik, Proboscids, Horses, Palaeozoic plant, spores, pollens); Basic concepts of ecology/palaeoecology; classification – ecological and taxonomic schemes; plurality and formations; fossils and palaeoenvironments.

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 and forming processes; ore-rock associations (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 tectonics, 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 (landslides, volcanic, earthquakes, cyclones), 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: GEOPHYSICS

Solid 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 (GNSS systems: GPS and GLONASS); Levelling and Surveying.

Earthquake Seismology: Elements of elasticity theory - stress and strain tensors; Generalized Hooke's Law; Body and Surface Waves; Rotational, dilatational, irrotational and solenoidal waves; Reflection and refraction of elastic waves; inhomogeneous and evanescent waves and bounded waves; Eikonal Equation and Ray theory; earthquake-causes and measurements, magnitude and intensity, focal mechanisms, earthquake quantification, source characteristics, seismotectonics and seismic hazards; digital seismographs, Earthquake statistics; wave propagation 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 borehole gravity surveys; Instruments, gravity sensors and surveys; various corrections for gravity data reduction – free air, Bouguer and isostatic anomalies; density

estimates of scalar regional and residual gravity separation; principle of isostasy; gravity anomalies, 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; Euler deconvolution, 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 Resistivity Sounding and Profiling, Various electrode arrangements, application of linear filter theory, Sounding curves over multi-layered earth, Dar-Zarrouk parameters, reduction of layers, Principle of equivalence, interpretation of resistivity field data. Principles of equivalence and suppression, self-potential method and its origin. Electrical Resistivity Tomography (ERT), Induced polarization, time and frequency domain IP measurements; interpretation and applications of SP, resistivity and IP data sets for groundwater exploration, mineral exploration, environmental and engineering applications.

Electromagnetic Methods: Electromagnetic spectrum, EM elements used, Maxwell's equation, Helmholtz 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 methods; EM data processing, processing, interpretation; Ground Penetrating Radar (GPR) methods; effect of conducting overburden. Geological applications including groundwater, mineral 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 noises 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 interpretation.

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, lithologs and mineral identification, CBL/VDL sequence, porosity characterization, cement bond logging, micro-logs. Pulsed Neutron Devices and Spectroscopic Multi-Array and Thermal Neutron 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, semi-conductor 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 L∞ norms, over-determined, under-determined 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 values 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 dc excitation.

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

microcontroller 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 Spectrophotometers, 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, eigen values and eigen vectors, 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.

PE 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 rule; 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 belts; kinematics and dynamics of particles and of rigid bodies in plane motion, including work and energy, momentum and impulse and collisions; impact of elastic bodies.

Mechanics of Materials: Stress and strain, stress-strain relations, 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 slider-crank, crank and rocker mechanisms; gear trains; flywheels and governors; balancing of reciprocating and rotating masses; gyroscope.

Introduction: 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 2: 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 of 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, Kirchhoff's 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 cycles involving steam and ideal gases, 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 3: 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 metal forming; deep drawing, bending; mass 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; Probability theory; 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 methods and machines; Explosives and blasting, blasting devices and 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; Ground control, instrumentation and 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 3: 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: winding systems, haulages, conveyors, face and development machinery, hoisting systems, pumps, crushing and comminution methods and machinery.

Section 4: 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 air flow, distribution, natural and mechanical ventilation; Mine fans and usage; Auxiliary ventilation; Ventilation survey and planning; Ventilation network.

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 5: 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 constraints; 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, truck-shovel 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 – aluminium, 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 ironmaking (COREX, MIDREX).

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 – homogenization 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: nucleation, growth, 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: dislocation 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 aluminium alloys.

Powder metallurgy: production of powders, compaction and sintering.

Non-destructive testing (NDT): Eddy current, ultrasonic, radiography, and current, acoustic emission and magnetic particle inspection methods.

NM – Naval Architecture and Marine Engineering

Section 1: Engineering Mathematics

Determinants and matrices, systems of linear equations, eigen values and eigen vectors. Functions, gradient, divergence, curl, chain rule, partial derivatives, directional derivatives, definite and indefinite integrals. Line, surface and volume integrals; theorems of Gauss, Stokes 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; deflection; Euler's theory of columns; energy methods; fracture 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 techniques 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; hydrodynamic lift, Kutta-Joukowski theorem; Stokes motion– Fundamental concepts; control volume approach to Euler's law, laminar, viscous flow, turbulent 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.

Bernoulli 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. Linearized 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. Hydrostatics 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 and Propulsion: Components of ship resistance, Froude theory, hull roughness, model testing and ship resistance prediction methods, tank wall effects, determination of ship resistance [illegible], resistance of high speed vehicles, appendage and added resistance. Geometry of screw propeller, propeller theories, hull-propeller interactions, different propulsive efficiency definitions. Propeller cavitation and effects. Propeller design procedures. Open water and self-propulsion model tests. Different types of propulsors and their working principles. Propeller material, strength and manufacturing. Unconventional propellers.

Ship Manoeuvring and Control: Ship path keeping and changing, equations of motion. Linearized equations and control fixed stability. Rudders, rudder types, 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, statistical: wave spectrum, encounter frequency. Types of ship motions, uncoupled and coupled motions, equations of motion. Dynamic effects of ship motion in seaway. Different ship motion stabilizers - 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 and Strength: Shipbuilding materials, joining techniques, ship structures and framing systems - bottom, side, deck, bulkhead, end structures, superstructure 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, different static 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 – linear and non-linear waves, and their importance. Offshore Structures: Fixed offshore platforms – Jackets, Gravity platforms, Floating platforms – semi-submersibles, Jackups, TLPs, FPSOs, Mooring, station keeping. Port and Harbour Engineering: Ports and Harbours, Port structures – Jetties, Dolphins, Liquid berths, Drydocks, Breakwater.

Section 8: 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. Practical applications of one-dimensional steady flow process, flow energy, steady flow energy equation (SFEE). 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, Rankine cycle, Brayton cycle, Stirling cycle etc.; Air standard cycles: Otto, Diesel, Dual and Joule cycles. 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: Diesel engine principles, low speed and medium speed diesel engines. Two and Four stroke engines. Scavenging and turbo charging. Fuel oil system. Lubricating oil systems, cooling systems, local and remote measurement. Starting air systems and reversing systems, controls and safety devices. Couplings and Clutches. 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, wheels, 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, feed water treatment.

Engine Dynamics: Torsional vibration of engine and shafting, axial shaft vibration, critical speeds, engine rating, rating corrections, fuel additives. Relationship of engine to Recognized 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 – fire 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. Deck machinery and cargo handling systems. Propulsion and steering gear systems.

PE Petroleum Engineering

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

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 mechanisms 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, foam 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, eigen values and eigen vectors; 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: inertia 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; Kramers-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; governers and fly wheels; design of bolted, riveted and welded joints; interference/shrink fit joints; Principles of 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, boundary

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, wire and tube 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, ISO 14000.

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, concept of JIT manufacturing system; 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: Limits, continuity, monotone functions, uniform continuity, differentiability, Rolle's theorem, mean value theorems, Taylor's theorem, L'Hospital rule, maxima and minima, Riemann integration and its properties, improper integrals; Functions of several real variables: Limits, 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 $\mathbb{R}^n$ 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 $\mathbb{R}^n$ 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: Joint 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, Eigen values and Eigen vectors.

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 nonlinear 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 structure 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; Process of manufacture 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, bicomponent spinning and gel spinning; Spinning of viscose, lyocell and other regenerated cellulosic fibres such as cuprammonium and acetate; 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 and 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 drafting; Roller arrangements in drafting systems; Periodic mass variation in drawn sliver; Draw frame auto leveller; Principles of cotton combing; Combing cycle and mechanism; Recent developments in combing machine; Principles of drafting, twisting, and bobbin building in roving formation; Recent developments in roving machine; Principles of drafting, twisting and cop building in ring spinning; Causes of end breakages; Recent 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 twistless yarn 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 relationship 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 eccentricity 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.

Principles 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

Web/batt preparation processes for nonwovens; Web formation and bonding processes; Spun-bonding and melt blowing technologies; Applications of nonwoven fabrics.

Principles of braiding; Types of braids; Modern braiding technology.

Peirce's equations for plain woven fabric geometry; elastic thread model of plain woven fabric; thickness, cover and maximum sett 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 fibres, rovings and yarns; Twist and hairiness of yarns; 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 fibres; Singeing; Chemistry and practice of preparatory processes for cotton; Preparatory processing of wool and silk; Mercerization of cotton; Preparatory processes for manmade fibres and their blends; Optical brightening agents.

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.

[illegible] finishing of cotton: [illegible], anti-crease finishes, water repellent, flame retardant and enzymatic bio-polishing finishing of cotton, [illegible] and [illegible] finishing of wool, [illegible] and [illegible] finishing, heat setting of synthetic fabrics. Minimum application techniques.

Pollution control and treatment of effluents.

GE-A : Engineering Mathematics (Compulsory to all GE candidates)

Section 1: Linear Algebra

Algebra of real matrices, Determinants, inverse and rank of matrix, System of linear equations, conditions for unique solution, no solution and infinite number of solutions, Eigen values and eigen vectors of matrices, Properties of eigen values and eigen vectors of symmetric matrices, diagonalization of matrices, Cayley-Hamilton Theorem.

Section 2: Calculus

Functions of single variable, limit, continuity and derivability, mean value theorems, indeterminate forms and L'Hospital's rule, continuity and differentiability, Taylor series, maxima and minima, saddle points, Fundamental theorem and mean value theorems of integral calculus, Evaluation of definite and improper integrals, Applications of definite integral to evaluate areas and volumes, Evaluation of a curve about an axis.

Functions of two variables, limit, continuity and partial derivatives, directional derivatives, 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, Euler-Cauchy equation, Second order linear differential equations with variable coefficients, reduction of order, method of variation of parameters, Eigen value problems 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, pathline, streakline 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 3: 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 4: 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 microstructures.

Reaction kinetics, fundamentals of diffusion, Fick's laws, their solutions and applications.

Solidification in pure metals and alloys, nucleation and growth, diffusional solid state phase transformations: precipitation and coarsening, 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.

ii. 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.

iii. 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-C: 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 behavior 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. Factors 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, Melting 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; Specialty 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 plasticizers, 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 rheometer, parallel plate, cone-and-plate rheometer. Viscoelasticity-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, [illegible].

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, Coefficient 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 on 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-oxidants, nutraceuticals, nutrient deficiency diseases.

Chemical and biochemical changes: Changes occurring 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, 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 packaging and storage: packaging materials, aseptic packaging, controlled and modified atmosphere storage. Cereal processing and products: milling of rice,

wheat, and pulses; processing of 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 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 Fick'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: Psychrometry, humidification and dehumidification operations.

XE-H Atmospheric and Oceanic Sciences

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, Centrifugal, Centripetal 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, Wind and Surface Waves, Wind-driven Circulation, Ekman and Sverdrup Transports, Storm Surges, Tides, Tsunamis and Wind Waves, Gyres and Eddies, Western and Eastern 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 [illegible].

XH-B1	**Reasoning and Comprehension** **(Compulsory for all XH candidates)**

This section aims 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 GMAT, GRE, LSAT etc.), and analysis of the text and its stylistic and rhetorical structure.

Questions in this section shall involve the following areas:

- Reading Comprehension: Ability to understand complex language material in short passages 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: Including the ability to evaluate or to predict an argument, identify the main and supporting arguments, predict outcomes etc.

XH-C1: Economics

21.1 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 Equilibrium; 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 – Monopsonistic Exploitation; General Equilibrium analysis; Welfare Economics: Fundamental Theorems; Social Welfare Function; Efficiency Criteria: Pareto-Optimality.

21.2 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 q, Keynesian Stabilization Policies; Investment 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.

21.3 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.

10.4 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.

10.5 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.

10.6 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: PQLI, HDI, GDI, GEM; Poverty and Inequalities – Concepts and Measurement; Social Sector Development: Health, Education, Gender; Fertility, Morbidity, Mortality, Migration, Child Labor, Age Structure, Demographic Dividend; Models of Economic Growth: Harrod-Domar, Solow, Kaldor; Technical progress – Disembodied & embodied; Endogenous growth models.

10.7 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; Role of Foreign Capital, Trade Policies, Infrastructure Development: Physical and Social; Public-Private Partnerships; Reforms in Land, Labour and Capital Markets; Poverty, Inequality & Unemployment; Effectiveness 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; Composition/direction 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-fictional prose—with emphasis on the long 19th and 20th centuries.

C2.2 Literatures, in a comparative context, originally or in English translation, translated from India and, 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 that 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 give more importance to conceptual depth and methodological sensitivity demonstrative of disciplinary training over information, wherever possible.

XII-C3 : Linguistics

03.1 Language and Linguistics

Language: spoken, written and signed; description and prescription; language and culture; heritage language and social identity; language as an object of inquiry – its structural units and components; design features; writing systems; biological foundations and language faculty; linguistic competence and performance; levels in grammar; contexts 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.

03.2 Levels of Grammar and Grammatical Analysis

a. Phonetics and Phonology: Vocal tract anatomy; phonation; articulatory parameters; classification of sounds; gestural theory; phoneme 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; organization of phones into phonemes; phoneme inventories and cross-linguistic properties; syllable structure and phonotactic properties; principles of phonological analysis – phonetic similarity, contrastive and complementary distribution, free variation; autonomous, classical and generative approaches; levels of representation; phonological rules; distinctive features; major class, manner, place, etc.; feature geometry; rule ordering; markedness and underspecified feature 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; content and word types of morphemes – structural and functional; affixes as ... ; grammatical categories; morphological theories – paradigmatic, lexicalist, process and distributed morphology; identification of morphemes and parts of speech; alternations; morphophonology; inflection vs. derivation; conjugation and declension; word creation and word formation rules and processes; creativity and productivity; blocking; bracketing paradoxes; conditions on affix ordering; mental lexicon; lexical categories; lexical-semantic operations.

c. Syntax: Basic syntactic units and their types: word, phrase, clause, sentence and their description and generation; grammatical and case relations, key ideas forming classic theories; Generative Grammars including Minimalist Program, HPSG, Relational Grammar and Lexical Functional Grammar; phrase structure rules; X-bar theory; universal grammar and cross-linguistic properties; role of grammaticality judgements; solving the language acquisition problem; diagnostics of structure; syntactic phenomena such as movement, binding, ellipsis, wh-questions, islands, argument structure etc.; complements and unaccusatives.

3. Semantics and Pragmatics: Types of meaning; lexical and compositional; syntax-semantics interface; semantic roles; binding; scope; LF; deixis; sense and reference, connotation and denotation; lexical semantic relations (homonymy, hyponymy, polysemy, 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; indefiniteness; 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.

C2.2 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 leveling; relative chronology of different changes; study of sound change in progress; morphosyntactic syncretism, grammaticalization and lexicalization; and semantic change (extension, narrowing, figurative speech); linguistic reconstruction - internal vs. external; the comparative method; lexicostatistics; language contact and dialect geography - borrowing and impact of borrowing; pidgins and creoles; bi- and multilingualism as the source of borrowing; dialect geography - dialect atlas; isogloss; focal, transition and relic areas.

C2.3 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; standard language; linguistic variables and their co-variation along sociocultural dimensions; language policies and development (education, media); 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; endangerment scale; parameters of endangerment; documentation and revitalization.

C2.4 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.

[illegible] Methods of Analysis

Experimental and non-experimental methods, sampling procedures, identification of variables and their relations; data processing and interpretation; quantitative analysis of data; ethnomethodology; participant observation; field methods and elicitation; documentation/creation of artifacts.

[illegible] Applied Linguistics

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.

XY-C4 Philosophy

C4.1 Classical Indian Philosophy

C4.1.1 Orthodox Systems: **Sāṁkhya**: Puruṣa, Prakṛti, Guṇas, Satkāryavāda, Theory of Evolution, Pramāṇas and Theory of Error; **Yoga** – Pramāṇas, Theory of Error, Citta, Citta-vṛtti, Kleśa, Aṣṭāṅga yoga, Kaivalya, Īśvara; **Nyāya** – Pramāṇas, Hetvābhāsa, Īśvara, Asatkāryavāda, Theory of Error, Jñāna-lakṣaṇa; **Vaiśeṣika** – Paramāṇukāraṇavāda, Padārtha categories, Theory of Causation (Asatkāryavāda); **Mīmāṁsā** – Dharma, Apūrva, Pramāṇas, Pramāṇas in Kumārila and Prabhākara, Anyathākhyāti; and **Vedānta** – Advaita, Brahman, Īśvara, Māyā, Jīva, Mokṣa, Viśiṣṭādvaita: Pariṇāmavāda, Māyā, and Refutation of Advaitavāda, Dvaita, Dvaitādvaita, Śuddhādvaita, Pramāṇa in Advaita and Viśiṣṭādvaita.

C4.1.2 Heterodox Systems: **Cārvāka** – Pramāṇa, Indian materialism and Hedonism; **Jainism** – Anekāntavāda, Syādvāda, Anekāntavāda, Realistic categories, Jīva and Ajīva, Mokṣa, Pañcavrata, Anuvrata; **Buddhism** – Tripiṭaka, Sarvāstivāda, Sautrāntika, Mādhyamika, Yogācāra-vijñānavāda, Pratītyasamutpāda, Kṣaṇikavāda, Anātmavāda, doctrine of momentariness; Doctrine of Dependent Origination, Anātmavāda, Doctrine of Four Truths, Doctrine of Nirvāṇa, Bodhisattva, Brahmavihāras, Pāramitās, and Bodhisattva ideal, and Upāyakauśalya.

C4.1.3 Upaniṣads, Bhagavadgītā, and Dharmaśāstras: Philosophy of the Upaniṣads – Ṛta, Humans, Brahman and Ātman, Pañcakośa, Para-vidyā and Aparā-vidyā, Meaning of Dharma, Its Foundations, Śreyas and Preyas, Varṇāśrama-dharma, Dharma: Sādhāraṇa-dharma and Viśeṣa-dharma, Ṛṇa, Yajña, Karmayoga, Sthitaprajña, Lokasaṁgraha, and Law of Karma.

C4.1.4 Advaitavedānta, Śaivasiddhānta, Vaiṣṇavism, Śāktism and Vīraśaivism: Advaitavedānta – Nirguṇa Brahman, Rise and Self, and Connection of Māyā, Śaivasiddhānta – Pati (Lord) and Paśu-Pāśa (bond), Proofs for God's Existence, Bondage and Liberation, Vaiṣṇavism – Philosophical basis of Vaiṣṇavism, Śāktism – Philosophical basis of Śāktism, and Vīraśaivism – Philosophical basis of Vīraśaivism.

C4.2 Contemporary Indian Philosophy

C4.2.1 Vivekananda: Nature 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 Nature of God. **Tagore**: Humanism and Nature of Man, Nature of Religion, and Nationalism. K. C. **Bhattacharyya**: Concept of Absolute and Its Alternative Forms, and Subject, Subjectivity and Freedom. **Radhakrishnan**: Nature of Ultimate Reality, Religious Experience, Intellect and Intuition, Hindu View of Life. J. **Krishnamurti**: Nature of Freedom, Choiceless Awareness, Truth is a Pathless Land, and Nature of Education. **Gandhi**: Nature 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.

04.3 Classical and Modern Western Philosophy

04.3.1 Metaphysics: Pre-Socratic Philosophy of Thales, Anaxagoras, Anaximenes, Anaximander, Pythagoras, Parmenides, Heraclitus and Democritus. Metaphysics of Plato and Aristotle: The question of Being (ontology); Sense and 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, Monism, Pluralism, 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.

04.3.2 Epistemology: Plato and Aristotle's Theory Of Knowledge, Doxa, Episteme, and Noesis; Method of Dialectics, Theoretical and Practical Reason, Theory of Causation. Descartes Method of Doubt, Cogito ergo sum, Innate ideas and its refutation, Principle of non-contradiction, Sufficient Reason, and Identity of Indiscernibles. 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.

04.3.3 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, Goodwill, 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.

04.3.4 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.

04.3.5 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 to test the validity of arguments, Difference between Deductive and Inductive Logic, Causality and Mill's Methods.

04.4 Contemporary Western Philosophy

04.4.1 Frege's Sense and Reference; Logical Positivism's Verification theory of meaning; Elimination of Metaphysics; Frege's Distinction between Sense and Reference; Defence 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 conception 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 Pragmatic Epistemology with focus on inquiry, tradition and experience, education; Nietzsche on the Critique of Enlightenment, Will to Power, Genealogy of Morals; Richard Rorty's Critique of Representationalism, Against Epistemological method, Edifying Philosophy; Levinas: Ethics as a First Philosophy; Rawls: Veil of Ignorance, Principles 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 Standpoint, Strong 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 Empirical 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 questionnaire (Survey), observation, Experimental, Quasi-experiments, 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. Process of test construction: Standardization of measures, Reliability, Validity, Norms; Application of assessment and measurements in Tests– Applications of psychological testing in various settings- educational, counseling and guidance, clinical, organizational and developmental.

C5.3 Biological and Evolutionary basis of Behaviour: Heredity and behaviour: Evolution and natural selection; Nervous system, structure of the brain and their functions; Neuronal 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).

08.4 Perception, Learning, Memory and Forgetting: Vision & 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.

08.5 Cognition: Thinking, Intelligence and Language: Basic elements of thought: Concepts, Propositions, Imagery; Current perspectives 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, Sternberg and Emotional intelligence; measuring intelligence; individual differences in intelligence; Role of heredity and environment; Difference between intelligence, aptitude and creativity.

08.6 Personality: Theories of personality: Psychoanalytic, behavioristic, social cognitive view, humanism and trait and type theories; Biology of personality and assessment of personality.

08.7 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, Cannon-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 and emotion-focused coping; PTSD and meditation.

08.8 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.

08.9 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.

08.10 Applications of Psychology: Psychological disorders: Conceptions of mental disorders; assessment and diagnosis; DSM and other tools; PTSD and Trauma; Psychotherapies: Psychodynamic, Phenomenological/Humanistic 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 Pakistani society including environmental...

AH-08 Sociology

08.1 Sociological Theory

08.1.1 Classical Sociological Traditions: Emile Durkheim: Social solidarity, Social Facts, Religion, Functionalism, Suicide, Anomie, Division of labour; 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.

08.1.2 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 functions), Claude Levi Strauss (Myths, Structuralism).

08.1.3 Phenomenological and Interactionist Traditions: G.H. Mead, Alfred Schutz (Phenomenology), Harold Garfinkel (Ethnomethodology), Erving Goffman (Symbolic Interaction, dramaturgy), Clifford Geertz (Culture, thick description).

08.1.4 Post-modernism, Post-Structuralism and Post-Colonialism: Pierre Bourdieu, Michel Foucault, Jurgen Habermas, Anthony Giddens, Manuel Castells.

08.1.5 Conflict Theory: Ralf Dahrendorf, C Wright Mills.

08.1.6 Indian Thinkers: M.K. Gandhi, B.R. Ambedkar, Radhakamal Mukherjee, G.S. Ghurye, M.N. Srinivas, Irawati Karve.

08.2 Research Methodology and Methods

08.2.1 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.

08.2.2 Research Design: Reading Social Science Research, Data and Documents; Induction and Deduction; Fact, Concept and Theory; Hypotheses, Research Questions, Objectives.

08.2.3 Quantitative and Qualitative Methods: Ethnography; Survey Method; Historical method; Comparative method.

08.2.4 Research Techniques: Sampling; Questionnaire and Schedule; Statistical Analysis; Observation, Interview and Case study; Interpretation, Data Analysis and Report Writing.

08.3 Sociological Concepts

08.3.1 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; Civil society.

08.1.1 Social Institutions: Marriage, Family and Kinship; Economy; Polity; Religion; Education; Law and Customs.

08.1.2 Social Stratification: Social Difference, Hierarchy, Inequality and Marginalization; Caste and Class; Status and Power; Gender, Sexuality and Disability; Race, Tribe and Ethnicity.

08.1.3 Social Change: Evolution and Diffusion; Modernization and Development; Social Transformations and Globalization; Social Mobility; Industrialization; Educational and Occupational change.

08.4 Agrarian Sociology and Rural Transformation: Rural and Peasant Society; Caste-tribe distribution 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; Pauperism; Mode of production debate; Land reforms; Panchayati Raj; Rural development programmes and community development; Green revolution and agricultural change; Peasants and farmers movements.

08.5 Family, Marriage and Kinship: Theoretical Approaches: Structural-functionalism, Alliance and Cultural; Gender Relations and Power Dynamics; Inheritance, Succession and Authority; Gender, Sexuality and Reproduction; Children, Youth and Elderly; Divorce and Family; Emergent Forms of Family; Changing Marriage Practices; Changing Care and Support Systems; Family Laws; Domestic Violence and crime against women; Honour Killing.

08.6 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, A.R. Desai, D.N. Dhanagare); Village studies; Communalism and Secularism.

08.7 Social Movements

08.7.1 Introduction to Social Movements: Nature, Definitions, Characteristics; Social Movement and Social Change; Types of Social Movements: Reform, Rebellion, Revival, Revolution, Insurrection, Counter Movement.

08.7.2 Theories of Social Movements: Structural-functional; Marxian; Resource Mobilization Theory; New Social Movements.

08.7.3 Social Movements in India with Specific Reference to Social Bases, Leadership, Ideology and Actions: Peasant movement; Labour movement; Dalit movement; Women's movement; Environmental movement.

08.1.4 Social Movements, Civil Society and Globalization: Social movements and its relationship with state and civil society; Social movements and impact of globalization; Debates; issues of citizenship.

08.2 Sociology of Development

08.2.1 Perspectives on the Study of Development: Definitions and indices; Liberal, Marxist and Gandhian Perspectives; Dependency theory; World Systems; Subaltern/ecological critiques of development.

08.2.2 State and Market: Institutions and Ideologies; Planned Development and Social Globalization and Liberalization.

08.2.3 The Micro-Politics of Development: Transforming Democracies: Plans and Protests; Knowledge and Power in Development; Re-inventing Development; Subaltern Movements; Participatory Development; Decentralization and devolution; Participatory approaches.

08.2.4 Sustainable Development: Post-sustainable development; Development, Poverty and Inequality; Poststructural perspectives; ecology; Alternative development paradigms; Capabilities and 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, M.O. and V.B. 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, colour, 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 potential, 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 2: 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 Kharash effect. Elementary sigmatropic reactions, Grignard reagents and their uses. Aromatic electrophilic substitutions, orientation effect as exemplified by various functional groups. Identification of common functional groups by chemical tests.

Section 3: 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 biomolecular purification-ion exchange and gel filtration chromatography. Identification of these biomolecules and their components.

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; Cells 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 histocompatibility complex; Immunological techniques: Immunodiffusion, immunoelectrophoresis, RIA and ELISA, flow cytometry; monoclonal antibodies and their applications.

XL-P 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; Botanic for plant taxonomy and herbaria.

Section 2: Plant Anatomy

Anatomy of root, stem and leaves, floral organs, embryo and young seedlings. Primary and secondary meristems, stelar 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, signaling mechanisms in Arabidopsis and Antirrhinum, 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 in 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, brassinosteroids, ethylene, strigolactone, abscisic acid, salicylic and jasmonic acids. Senescence and programmed cell death.

Section 5: Genetics and Genomics

Cell cycle and cell division. Principles of Mendelian inheritance, linkage, recombination, genetic mapping; extrachromosomal inheritance; introduction to epigenetics; gene silencing; transgene silencing; post-transcriptional gene silencing; miRNA and siRNA; transposon and

organization of eukaryotic genome structure; gene expression; gene mutation and repair; chromosomal aberrations (numerical 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 (Meganucleases, CRISPR-Cas 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 plants as fiber economy; genetically modified crops and its regulation, e.g. 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; physiological 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 defense responses; salicylic acid (SA) and jasmonic acid (JA) in plant-pathogen and plant-herbivore interactions; mechanisms involved in plant-microbe interactions (such as Quorum sensing).

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; herbivores, parasites and mutualisms.

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; Biosynthesis

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 phages; 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, role 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, role 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

Types 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, 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 packaging 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 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 H: 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 Fick'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: psychrometry, humidification and dehumidification operations.

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Candidates must carefully [illegible] the [illegible] of the [illegible] and [illegible] their [illegible] candidature cancelled, rejection of admission, false [illegible] or incomplete [illegible] submission or [illegible] information [illegible] may be entered against all such candidates.

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Although GATE 2020 [illegible] all efforts to provide accurate [illegible] of Technology Roorkee (IITR), [illegible] Organizing Institute [illegible] responsibility for conducting GATE 2020. In case of any dispute or difference arising for reason of GATE 2020, the Hon'ble High Court for Roorkee, Uttarakhand shall have the exclusive jurisdiction to entertain and settle such disputes and claims.

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Contact Hours: Monday to Friday 10:00 AM to 5:00 PM (Government working days only)

Information contained in this brochure is version 1.0 as on 14th August 2024. There may be some changes in future due to unavoidable reasons. As and when any change happens, it will be notified on GATE 2025 website https://gate2025.iitr.ac.in/

IMPORTANT NOTE

1. In all matters concerning GATE 2025, the decision of the GATE 2025 Committee will be final, binding on all the applicants.
2. Although GATE 2025 will be held at different centres across the country, Indian Institute of Technology Roorkee is the Organizing Institute, and has the overall responsibility of conducting GATE 2025. In case of any claims or disputes arising in respect of GATE 2025, it is hereby made absolutely clear that the High Court of Nainital, Uttarakhand alone shall have the exclusive jurisdiction to entertain and settle any such disputes and claims.

Organizing Institute

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Roorkee 247667, India

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https://gate2025.iitr.ac.in

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End of Information Brochure