

# GATE 2020

GRADUATE APTITUDE TEST IN ENGINEERING

## INFORMATION BROCHURE



**Organising Institute**

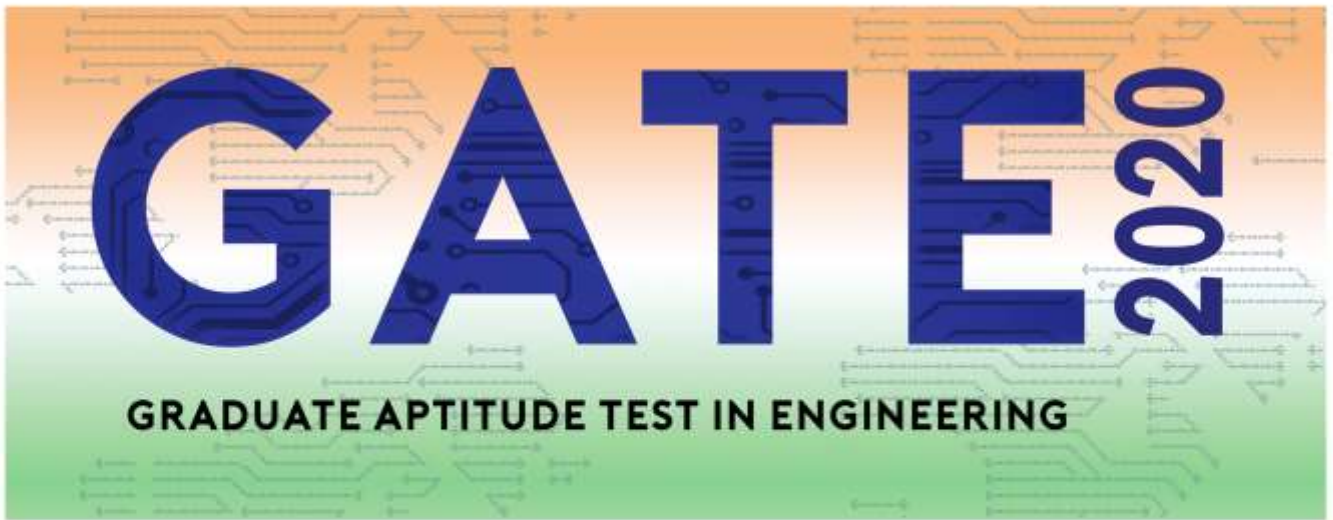
**Indian Institute of Technology Delhi**



**Contents as on July 20, 2019**

*Copyright © GATE 2020, Indian Institute of Technology Delhi*

---



## INFORMATION BROCHURE



**Organising Institute**

**Indian Institute of Technology Delhi  
Hauz Khas, New Delhi - 110016**



# Contents

1. Introduction.....	1
2. About GATE.....	1
2.1. Administration.....	1
2.2. Scholarship/Assistantship for Post-graduate Programs.....	2
2.3. Use of GATE score for Employment .....	2
3. About GATE 2020.....	3
4. Pre-Examination Related Information .....	5
4.1. Eligibility for GATE 2020.....	5
4.2. GATE 2020 Papers .....	7
4.3. GATE 2020 Examination Cities .....	8
4.4. Application Process .....	8
4.4.1 GATE 2020 Application Fee.....	9
4.4.2 GATE Online Application Processing System (GOAPS) .....	10
4.4.3 Filling in GATE 2020 Application.....	11
4.4.4 Identity Proof.....	12
4.4.5 PwD candidates and Scribe Related Guidelines.....	12
4.4.6 Supporting Documents .....	13
4.4.7 Photograph and Signature Requirements.....	14
4.4.8 Application Fee Payment Options .....	17
4.5. Application Scrutiny and Rectification .....	18
4.6. Admit Card .....	18
5. GATE 2020 Examination Related Information .....	19
5.1. Examination Duration .....	19
5.2. GATE 2020 Question Papers .....	19
5.2.1 Pattern of Questions.....	19
5.2.2 Marks .....	20
5.2.3 Design of Questions .....	20
5.3. Marking Scheme – Distribution of Marks and Questions.....	21
5.3.1 General Aptitude (GA) Questions .....	21
5.3.2 Question Papers other than GG, XE and XL.....	21
5.3.3 GG (Geology and Geophysics) Paper .....	21
5.3.4 XE Paper (Engineering Sciences).....	21
5.3.5 XL Paper (Life Sciences).....	22
6. Post-Examination Related Information.....	22
6.1. GATE Score.....	22
6.1.1 Calculation of Normalized Marks for Multi-session Papers .....	23

6.1.2	Calculation of GATE Score for All Papers .....	23
6.2.	GATE 2020 Results .....	24
6.3.	GATE 2020 Scorecard.....	24
7.	GATE 2020 at International Centres .....	24
8.	Frequently Asked Questions (FAQs).....	25
8.1.	Application Process .....	25
8.2.	Admit Card .....	29
8.3.	GATE 2020 Examination .....	29
8.4.	PwD and Dyslexic Candidates .....	31
9.	Contact Information .....	32
	Appendix A:Certificate from Head of the Department/Institute.....	33
	Appendix B: Qualifying Disciplines .....	34
	Appendix C .....	36
	Authorities Empowered to Issue SC/ST Certificates .....	36
	Person with Disability (PwD) Category .....	36
	Authorities empowered to issue Dyslexic Certificate.....	36
	Appendix D: Code of Conduct for GATE 2020 Examination.....	37
	Appendix E: Syllabus Content.....	38
	Appendix F: Guidelines for conducting Exam for PwD.....	85

## List of Tables

Table 2.1	Zones and the corresponding administrative institutes for GATE 2020 .....	2
Table 3.1	Important Dates related to GATE 2020.....	4
Table 4.1	Eligibility Criteria for GATE 2020 .....	5
Table 4.2	List of GATE 2020 Papers and Corresponding Codes.....	7
Table 4.3	List of Zone-wise Examination Cities for GATE 2020 .....	9
Table 4.4	Details of Application Fee for GATE 2020.....	10
Table 4.5	Sample Photographs .....	15
Table 4.6	Sample Signatures .....	16
Table 9.1	Contact details of Zonal GATE Offices .....	32

## 1. Introduction

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

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

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

## 2. About GATE

Graduate Aptitude Test in Engineering (GATE) is basically an examination on the comprehensive understanding of the candidates in various undergraduate subjects in Engineering/Technology/Architecture and post-graduate level subjects in Science. GATE 2020 will be conducted for 25 subjects (also referred to as “papers”) and it would be distributed over 1<sup>st</sup>, 2<sup>nd</sup>, 8<sup>th</sup> & 9<sup>th</sup> of February 2020. The GATE examination centres are spread in different cities across India, as well as, in six cities outside India. The examination would be purely a Computer Based Test (CBT).

The GATE score would reflect the relative performance level of the candidate in a particular subject, which is quantified based on the several years of examination data. Note that the GATE 2020 score is valid for **THREE YEARS** from the date of announcement of the results.

### 2.1. Administration

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

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

One of the administering institutes is designated as the **Organising Institute** (OI), and it would be responsible for the end-to-end process, as well as, the overall coordination amongst the administering institutes for conducting the **GATE Examination**. The **Organising Institute** for GATE 2020 is **Indian Institute of Technology Delhi (IITD)**.

**Table 2.1 Zones and the corresponding administrative institutes for GATE 2020**

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

## **2.2. Scholarship/Assistantship for Postgraduate Programs**

To avail the financial assistance (scholarship/assistantship), the candidate must first secure the admission to a program in one of the central government supported institutes, by a procedure that could vary from institute to institute. Depending upon the norms adopted by a specific institute or department of the institute, a candidate may be admitted directly into a course based on: his/her performance in GATE only; **or** based on his/her performance in GATE **and** an admission test/interview conducted by the department to which he/she has applied **and/or** the candidate's academic record. In the test/interview based selection procedure, as per the MHRD guidelines, a minimum of 70% weightage will be given to the performance in GATE and the remaining will be given to the candidate's performance in test/interview and/or academic record. However, the admitting institutes could prescribe a minimum passing marks in the test/interview.

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

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

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

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

## **2.3. Use of GATE score for Employment**

In the past, several Public Sector Undertakings (PSUs) have used GATE scores to shortlist the candidates for employment. A few such organizations are: Bharat Heavy Electricals Limited (BHEL), Gas Authority of India Limited (GAIL), Hindustan Aeronautics Limited (HAL), Indian Oil



Corporation Limited (IOCL), National Thermal Power Corporation (NTPC), Nuclear Power Corporation of India Limited (NPCIL), Oil and Natural Gas Corporation (ONGC) and Power Grid Corporation of India (PGCI).

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

Some other Government of India Organizations have also expressed their interest to utilize GATE 2020 score for their recruitment purpose.

**Note: GATE administration is not responsible for employment opportunities. The qualified candidates must check newspapers and other reliable sources for any such information.**

### 3. About GATE 2020

- IIT Delhi is the organising institute for GATE 2020.
- Information website for GATE 2020 is <http://gate.iitd.ac.in>
- GATE 2020 will be conducted on 25 subjects (also referred to as “papers”).
- Examination for all the **25 subjects** (papers) will be conducted as ONLINE Computer Based Test (CBT).
  - The online examination paper will contain some questions for which numerical answers must be keyed in by the candidate using a virtual keypad. Rest of the questions will be of Multiple Choice Question (MCQ) type. The Candidates will use **ONLY** an on-screen virtual calculator provided for the examination.
- A candidate can appear **only** in **ANY ONE** paper of the GATE examination.
- GATE 2020 examinations will be held during the forenoon and afternoon sessions on 1<sup>st</sup>, 2<sup>nd</sup>, 8<sup>th</sup> & 9<sup>th</sup> of February 2020.
  - Examination for some of the papers in GATE 2020 may be held in multiple sessions. However, a candidate can appear for the examination in **one session ONLY**.
  - Exact details of the complete examination schedule will be notified later on the GATE 2020 website.
- Candidates have to register and fill the application via **ONLINE mode ONLY** at GATE Online Application Processing System (GOAPS). The link will be made available on GATE 2020 website <http://appsgate.iitd.ac.in>.
  - 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 his/her application form/documents etc. to IIT Delhi or any of the zonal GATE offices.

- The payment of application fees is through electronic mode.
- The Admit Cards for GATE 2020 would be available only on GOAPS website. Candidates can download their Admit Card from GOAPS website. 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 Date/Time specified in the Admit Card will be entertained. Similarly, this being an examination body with certain constraints, candidates needing very special or specific facility for the examination may not be entertained. Hence, candidates are requested to adhere to the facilities that are possible within the ambit and resources of GATE Examination Body.
- Important dates for GATE 2020 are given in **Table 3.1**.

**Table 3.1 Important Dates related to GATE 2020**

<b>GATE Online Application Processing System (GOAPS) Website Opens</b>	<b>Tuesday</b>	<b>3<sup>rd</sup> September 2019</b>
<b>Closing Date for Submission of (Online) Application (through Website)</b>	<b>Tuesday</b>	<b>24<sup>th</sup> September 2019</b>
<b>Extended Closing Date for Submission of (Online) Application (through Website)</b>	<b>Tuesday</b>	<b>1<sup>st</sup> October 2019</b>
<b>Last Date for Requesting Change of Examination City (an additional fee will be applicable)</b>	<b>Friday</b>	<b>15<sup>th</sup> November 2019</b>
<b>Admit Card will be available in the Online Application Portal (for printing)</b>	<b>Friday</b>	<b>3<sup>rd</sup> January 2020</b>
<b>GATE 2020 Examination Forenoon: 9:30 AM to 12:30 PM (Tentative) Afternoon: 2:30 PM to 5:30 PM (Tentative)</b>	<b>Saturday Sunday Saturday Sunday</b>	<b>1<sup>st</sup> February 2020 2<sup>nd</sup> February 2020 8<sup>th</sup> February 2020 9<sup>th</sup> February 2020</b>
<b>Announcement of the Results in the Online Application Portal</b>	<b>Monday</b>	<b>16<sup>th</sup> March 2020</b>

- Physical calculators, mobile phones and wristwatches are strictly prohibited and candidates possessing these in the examination hall (even if not using) will be disqualified.
- Biometric information (Photograph and Fingerprints) for randomly selected candidates may be captured before the start of the examination.
- In all matters concerning GATE 2020, the decision of the **GATE 2020 Committee** will be final and binding on all the applicants.
- Although GATE 2020 will be held at different test centres across the country, the Indian Institute of Technology Delhi, being the Organising Institute, bears the overall responsibility of conducting

GATE 2020. In case of any claims or disputes arising with respect to GATE 2020, it is hereby made absolutely clear that the Delhi High Court in New Delhi alone will have the exclusive jurisdiction to entertain and settle them.

- A new paper called “Bio-medical engineering (BM)” will be introduced in GATE 2020
- For candidates appearing for Geology and Geophysics (GG) papers, separate rankings will be provided based on their selection of sections (Refer FAQ).

## 4. Pre-Examination Related Information

### 4.1. Eligibility for GATE 2020

Before starting the application process, the candidate must ensure that he/she meets the educational eligibility criteria of GATE 2020, which are enumerated in [Table 4.1](#).

**Table 4.1 Eligibility Criteria for GATE 2020**

Qualifying Degree	Qualifying Degree/Examination	Description of Eligible Candidates	Year of Qualification not later than
B.E./ B.Tech./ B.Pharm.	Bachelor's degree holders in Engineering/Technology (4 years after 10+2 or 3 years after B.Sc./Diploma in Engineering/Technology)	Currently in the final year or already completed	2020
B. Arch.	Bachelor's degree holders of Architecture (5 years course)/Naval Architecture (4 years course)/ Planning (4 years course)	Currently in the final year or already completed	2020
B.Sc. (Research)/ B.S.	Bachelor's degree in Science (Post-Diploma/4 years after 10+2)	Currently in the 4 <sup>th</sup> year or already completed	2020
Pharm. D. (after 10+2)	Degree holders of 6 years program, consisting of internship or residency training during sixth year	Currently in the 4 <sup>th</sup> /5 <sup>th</sup> /6 <sup>th</sup> year or already completed	2022
M.B.B.S.	Degree holders of M.B.B.S. and those who are in the 7 <sup>th</sup> /8 <sup>th</sup> /9 <sup>th</sup> semester of such programme.	7 <sup>th</sup> , 8 <sup>th</sup> , 9 <sup>th</sup> or already completed	2020
M. Sc./ M.A./MCA or equivalent	Master's degree in any branch of Science/Mathematics/Statistics/Computer Applications or equivalent	Currently in the final year or already completed	2020
Int. M.E./ M.Tech. (Post-B.Sc.)	Post-BSc Integrated Master's degree programs in Engineering/Technology (4 years program)	Currently in the 2 <sup>nd</sup> /3 <sup>rd</sup> /4 <sup>th</sup> year or already completed	2022
Int. M.E./ M.Tech. or Dual Degree(after Diploma or 10+2)	Integrated Master's degree program or Dual Degree program in Engineering/Technology (5 years program)	Currently in the 4 <sup>th</sup> /5 <sup>th</sup> year or already completed	2021
Int. M.Sc./ Int. B.S.-M.S.	Integrated M.Sc. or 5 years integrated B.S.-M.S. program	Currently in the final year or already completed	2020
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	NA

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

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

The candidates who possess certification from any of the professional societies (IE, ICE, IETE, AeSI, IICChemE, IIM, IIE) and have enrolled on or before May 31, 2013 are also eligible to participate in GATE 2020. The candidates who have enrolled with these institutions after May 31, 2013 are not eligible, vide public notice (Advt No. P&AP/10(04)/2017). The advertisement can be found at <http://www.aicte-india.org/content/public-notice-professional-bodiesinstitutes-imparting-technical-education>.

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

- i) Must have completed or are in the final year of their Bachelor's degree (duration: at least 4 years) in Engineering/Technology or;
- ii) Must have completed or are in the final year of their Post Graduate (Master's) degree (duration: at least 2 years) in any relevant subjects in science.

**Note:** If a candidate is pursuing any higher degree or has already obtained a degree higher than that mentioned in the **Table 4.1**, the candidate should select the minimum required qualifying degree while filling the application form.

### **Documents Required in Support of Eligibility (Eligibility Documents)**

- In case, the candidate has already passed (in 2019 or earlier) one of the qualifying examinations listed in **Table 4.1**, he/she has to submit (i.e. upload) the **degree certificate/provisional certificate/course completion certificate/professional certificate/membership certificate** issued by the institute or society.
- In case, the candidate is expected to complete one of the qualifying criteria specified in **Table 4.1**, he/she has to upload a **Certificate from the Head of the Department/Institute** (in the format given in [Appendix A](#)) or a copy of marksheet for Section A of AMIE. This certificate must mandatorily have the signature and seal of the Head of Institute/Department with current date.

**Note:** Eligibility Document, as applicable, has to be uploaded only while filling the online application and **NOT** to be sent by post.

### **Qualifying Disciplines**

[Appendix B](#) gives a list of the qualifying disciplines. This list is only indicative and it is not necessary that the name of the candidate's degree has to be as per the table.

## 4.2. GATE 2020 Papers

GATE 2020 will be conducted on 25 subjects (papers). Table 4.2 shows the list of papers and paper codes for GATE 2020. A candidate is allowed to appear in **ONLY ONE** paper in **any ONE SESSION**.

Table 4.2 List of GATE 2020 Papers and Corresponding Codes

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

*XE Paper Sections	Code	**XL Paper Sections	Code
Engineering Mathematics (Compulsory)	A	Chemistry (Compulsory)	P
<b>Any two optional sections</b>		<b>Any two optional sections</b>	
Fluid Mechanics	B	Biochemistry	Q
Materials Science	C	Botany	R
Solid Mechanics	D	Microbiology	S
Thermodynamics	E	Zoology	T
Polymer Science and Engineering	F	Food Technology	U
Food Technology	G		
Atmospheric and Oceanic Sciences	H		

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

**Note:** CE and ME papers: Examination may be conducted in multiple sessions. However, a candidate is allowed to appear in only **ONE** specified session.

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

Candidates are expected to appear in a paper appropriate to the discipline of their qualifying degree. However, candidates are free to choose any one of the GATE 2020 papers as per their admission or employment plan, while keeping in mind the eligibility criteria for the institutions in which they wish to seek admission/employment. For more details regarding the admission criteria in any particular institute, the candidate is advised to refer to the website of that institute.

Candidates must learn about the paper code of their choice, as this information is essential during making the application, as well as, during the examination. As the candidates are permitted to appear in **ONLY ONE** of the 25 papers of the GATE 2020, they should make their choice (of the paper), with due care.

**After submission of application, any change of paper is NOT permitted.**

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

### **4.3. GATE 2020 Examination Cities**

**Table 4.3** gives a tentative list of the cities (zone-wise) in which GATE 2020 examination is planned to be held. Also given in the table are the details of the Zonal GATE Offices.

**Choice of Examination City:** The candidate can choose THREE cities from the list of examination cities given in **Table 4.3**. The first and second choices must be from the same GATE zone and third choice can be from any GATE zone.

If a candidate chooses a particular city (in a particular zone) as the first choice, then he/she will be able to choose the city of second choice ONLY from the same zone. However, third choice can be from any one of the listed cities (i.e., no restriction on the zone for the third choice city). Note that, because of the operational constraints, the GATE Committee reserves the right to add a new city or remove an existing one, and allot a city that may not be from any of the choices selected by the candidate.

### **4.4. Application Process**

Application for GATE 2020 must be submitted ONLINE (through GOAPS website, <http://appsgate.iitd.ac.in>) by paying necessary application fee. **For GATE 2020, all information related to the application process will be available in the GOAPS website. The photograph, signature, certificate of qualifying degree, category certificate (SC/ST/PwD) and/or Dyslexic certificate, wherever applicable, must be uploaded during the online application.** Candidates must enter the ID number specified in any one of the following IDs: Passport, PAN Card, Voter ID, Aadhaar-UID, College ID, Employee ID and Driving License. **The candidates**

who do not possess any of these identity cards, may please procure any one of them before making the application.

*Please note that the GATE application form is not available for sale or otherwise anywhere.*

**Table 4.3 Tentative List of Zone-wise Examination Cities**

Zone No.	Zonal GATE Office	Tentative List of Examination Cities/Towns*
1	<b>IISc Bangalore</b> Bengaluru - 560 012 Website: <a href="http://gate.iisc.ac.in">http://gate.iisc.ac.in</a>	Ananthapuramu, Angamaly, Bagalkot, Belagavi (Belgaum), Ballari (Bellary), Bengaluru South, Bengaluru North, Bidar, Chikkamagaluru, Davanagere, Kalaburagi (Gulbarga), Hassan, Hubballi (Hubli), Hyderabad, Kannur, Kasaragod, Kolar, Kozhikode, Kurnool, Malappuram, Mangaluru, Manipal, Mysuru (Mysore), Palakkad, Payyanur, Port Blair, Shivamogga (Shimoga), Thrissur, Tumakuru, Vatakara
2	<b>IIT Bombay, Powai,</b> Mumbai - 400 076 Website: <a href="http://gate.iitb.ac.in">http://gate.iitb.ac.in</a>	Ahmedabad, Ahmednagar, Amravati, Anand, Aurangabad, Baramati, Bhavnagar, Bhuj, Gandhinagar, Goa, Jalgaon, Kolhapur, Mehsana, Mumbai-Navi Mumbai-Thane, Nagpur, Nandad, Nashik, Pune, Rajkot, Ratnagiri, Sangli, Satara, Solapur, Surat, Vadodara
3	<b>IIT Delhi, Hauz Khas,</b> New Delhi – 110 016 Website: <a href="http://gate.iitd.ac.in">http://gate.iitd.ac.in</a>	Ajmer, Alwar, Bikaner, Faridabad-Palwal, Greater NOIDA, Gurugram, Hisar, Indore, Jaipur, Jammu-Samba, Jodhpur, Kota, Mathura, New Delhi, Rohtak, Srinagar, Sikar, Sonapat, Udaipur, Ujjain
4	<b>IIT Guwahati</b> Guwahati – 781 039 Website: <a href="http://iitg.ac.in/gate-jam">http://iitg.ac.in/gate-jam</a>	Agartala, Aizawl, Asansol-Durgapur, Bokaro Steel City, Burdwan, Dhanbad, Dibrugarh, Dimapur, Gangtok, Guwahati, Imphal, Itanagar, Jorhat, Kalyani, Muzaffarpur, Patna, Purnea, Shillong, Silchar, Siliguri, Tezpur
5	<b>IIT Kanpur</b> Kanpur – 208 016 Website: <a href="http://gate.iitk.ac.in">http://gate.iitk.ac.in</a>	Agra, Aligarh, Allahabad, Bareilly, Bhopal, Gorakhpur, Gwalior, Jabalpur, Kanpur, Lucknow, Varanasi
6	<b>IIT Kharagpur</b> Kharagpur – 721 302 Website: <a href="http://gate.iitkgp.ac.in">http://gate.iitkgp.ac.in</a>	Balasore, Berhampur (Odisha), Bhilai, Bhubaneswar, Bilaspur (CG),Cuttack, Eluru, Hooghly (WB), Jamshedpur, Kakinada (AP), Kharagpur, Kolkata, Raipur, Rajamahendravaram (Rajahmundry), Ranchi, Rourkela, Sambalpur, Srikulam, Vizianagaram, Tadepalligudem, Vijayawada, Visakhapatnam
7	<b>IIT Madras</b> Chennai – 600 036 Website: <a href="http://gate.iitm.ac.in">http://gate.iitm.ac.in</a>	Alappuzha, Aluva-Ernakulam, Attingal, Chengannur, Chennai South, Chennai West, Chirala, Chittoor, Coimbatore, Cuddalore, Dindigul, Gudur, Guntur, Idukki, Kadapa, Kanjirapally, Kanyakumari-Nagercoil, Karimnagar, Khammam, Kodad, Kollam, Kothamangalam, Kottayam, Madurai, Muvattupuzha, Namakkal, Nellore, Ongole, Pala, Puducherry, Salem, Thanjavur, Thiruvananthapuram, Thoothukudi, Tiruchirapalli, Tirunelveli, Tirupati, Vellore, Villupuram, Virudhunagar, Warangal
8	<b>IIT Roorkee</b> Roorkee – 247 667 Website: <a href="http://gate.iitr.ac.in">http://gate.iitr.ac.in</a>	Ambala, Amritsar, Bathinda, Dehradun, Ghaziabad, Haldwani, Hamirpur-Una (HP), Jalandhar, Karnal, Kurukshetra, Ludhiana, Meerut, Mohali-Chandigarh, Moradabad, NOIDA, Panipat, Pathankot, Patiala-Sangrur, Roorkee, Shimla-Solan, Yamunanagar
9	<b>International GATE,</b> IIT Delhi	Addis Ababa (Ethiopia), Colombo (Sri Lanka), Dhaka (Bangladesh), Dubai (UAE), Kathmandu (Nepal), Singapore

\* This is a tentative list, and any change will be updated on website: <http://gate.iitd.ac.in>

#### 4.4.1 GATE 2020 Application Fee

Details of the application fee are given in [Table 4.4](#). The application fee is NEITHER refundable NOR transferable. Payments have to be made online by using either net banking or debit card or credit card. As per the prevailing norms, additional online transaction charges or bank charges may be applicable. These charges will be specified on the payment portal.

**Table 4.4 Details of Application Fee for GATE 2020**

For Examination Centres in India	On or Before 24 <sup>th</sup> Sept. 2019	During the Extended Period
Female candidates	₹ 750	₹ 1250
SC/ST/PwD* category candidates	₹ 750	₹ 1250
All other candidates	₹ 1500	₹ 2000
For Examination Centres outside India (All Candidates)		
Addis Ababa, Colombo, Dhaka and Kathmandu	US\$ 50	US\$ 70
Dubai and Singapore	US\$ 100	US\$ 120

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

\*PwD means Persons with Disability.

#### 4.4.2 GATE Online Application Processing System (GOAPS)

**GOAPS:** <http://appsgate.iitd.ac.in> is the webpage/web address of the GATE Online Application Processing System (GOAPS). It can also be accessed from the GATE 2020 website (<http://gate.iitd.ac.in>).

GOAPS also provides an online interface to the candidate for interacting with the GATE administration. With this interface, a candidate can:

- Apply for the examination.
- Upload photograph, signature and other documents like qualifying degree certificate/ Certificate from the Head of the Department/Institute (in the format given in [Appendix A](#)) and category certificate (SC/ST/PwD) and/or Dyslexic certificate as applicable.
- Pay the application fee through any of the electronic payment modes.
- Check the Status of the application form: Received, Under scrutiny, Accepted, Defect status, Status after rectification, Rejected with valid reasons, Admit Card ready for download, etc.
- Download Admit Card.
- View his/her answers, marks and GATE score.
- Download GATE scorecard.

**GOAPS Registration:** A candidate must first register by providing Full Name (as per the qualifying degree certificate), a valid e-mail address, mobile number and by choosing a password. All communications from the GATE Offices will be sent to this e-mail address (**ONLY ONE PERSON CAN REGISTER WITH ONE e-mail ADDRESS**). Give the personal mobile number and e-mail address, because most of the communication will be through e-mail and/or SMS.

**GOAPS Enrollment ID:** Each GOAPS registered candidate will be provided with an Enrollment ID. Upon registration, an e-mail containing the GOAPS Enrollment ID will be sent to the candidate. This Enrollment ID will be the reference ID for all future communication.



**GOAPS Password:** The candidate has to choose a password during Enrollment at GOAPS. This password **must be remembered** along with the GOAPS **Enrollment ID** to login to GOAPS. 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 guessable string of numbers or letters like 12345 or abcd). **Keep your password information safe, secure and confidential.**

#### **4.4.3 Filling in GATE 2020 Application**

After due registration, GATE 2020 application must be filled and submitted ONLINE only at GOAPS.

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

**(i) Data Requirement for Filling the Application Form:** The following data will be required while filling the form at GOAPS:

- 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 exactly be the same as that in the qualifying degree certificate or the certificate issued by the Head of the Department/Institute in which the candidate is pursuing his/her study. GATE 2020 scorecard **will be issued as per the name entered in the application form.** Prefix/title such as Mr/Shri/Dr/Mrs/Smt, etc. should NOT be used before name.
- Address for Communication (including PIN code)
- Eligibility degree details
- College name and address with PIN code
- GATE paper (subject)
- 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 the Eligibility Certificate in pdf format (Degree Certificate or Provisional Certificate or Certificate from the Head of the Department/Institute (in the format specified in [Appendix A](#))
- 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

- Details of the valid Identity Document (ID)(The same ID, in original, should be carried to the examination hall)
- Net-banking/debit card/credit card details for fee payment

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

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

**(iii) Problems in Login into GOAPS:** In case of forgotten user ID or password, follow the instructions on the GOAPS portal to retrieve them.

#### 4.4.4 Identity Proof

Candidates have to specify **ANY ONE** of the following Identity Documents (IDs) during the online application process and enter the document number specified over there: **Passport, PAN Card, Voter ID, Aadhaar-UID, College ID, Employee ID or Driving License.** On the examination day, the candidate must bring the original ID proof along with the GATE 2020 Admit Card. Candidates will **NOT** be permitted to take the examination, in case the admit card and valid original photo identification document are not presented during the examination.

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

#### 4.4.5 PwD candidates and Scribe Related Guidelines

GATE 2020 will follow the revised guidelines as per the government regulations ([Appendix F](http://disabilityaffairs.gov.in/upload/uploadfiles/files/Guidelines-29_08_2018%20(1).pdf)). Refer: [http://disabilityaffairs.gov.in/upload/uploadfiles/files/Guidelines-29\\_08\\_2018%20\(1\).pdf](http://disabilityaffairs.gov.in/upload/uploadfiles/files/Guidelines-29_08_2018%20(1).pdf)

A PwD/Dyslexic candidate have the option of availing scribe assistance during the GATE 2020 examination. PwD/Dyslexic candidates can either arranged their own scribe or request GATE authority to arrange for the scribe during the application stage. The option exercised by the candidates in this regard within the prescribed time is final.

- The assistance that the Scribe can render to the candidate consists of **ONLY** reading the instructions and test paper displayed on the computer screen verbatim and in mouse-clicks, if the candidate is not able to do so.
- The Scribe shall not translate/interpret/emphasize the Test Paper Contents to the Candidate.

#### **(i) Scribes arranged by Candidates:**

- The Scribe should not be a candidate for a test paper in GATE 2020. According to the GoI (Government of India) guidelines, in case the candidate has opted to bring his/her Scribe, then the qualification of the Scribe should be one step below the qualification of the candidate taking the examination.

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

**(ii) Scribes arranged by GATE:**

- GATE Scribes will be used for those PwD/ Dyslexic candidates who have a priori opted for GATE Scribes.
- The qualification of the Scribe arranged by GATE will not be more than the minimum eligibility criteria of GATE. However, the qualification of the Scribe will be matriculation or above.
- If there are Y candidates who require scribe, it will be ensured that Y+1 scribes are available at the exam centre so that every candidate can have an alternative scribe to choose for the services. A PwD/ Dyslexic (similar learning disabilities) candidate who has been allowed to use a scribe has to choose from this panel. Candidates will not be permitted to bring their own scribe, if they have already opted for scribes to be arranged by GATE.

**(iii) Assistive Devices:** PwD candidates, if required can use assistive devices like Abacus, Braille slate, Wheel chair etc. PwD candidates desiring to make use of these devices have to arrange them, on their own and bring along with them, to the examination. GATE is not in a position to provide any of these assistive devices. However, since GATE 2020 is a Computer Based Test, candidate will be given an option to view the content on the computer screen in a magnified font (Step 1 magnification: approximately 1.25x, and Step 2 magnification: approximately 1.5x).

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

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

#### 4.4.6 Supporting Documents

**(i) Eligibility Documents**

Eligibility criteria and necessary details for the supporting documents are given in [Table 4.1](#) and in the paragraphs that follow the table.

**(ii) Category (SC/ST)Certificate**

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

**NOTE:** OBC-NCL 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 at least 40% impairment irrespective of the type of disability. The same document is required to be submitted to the admitting institution at the time of admission. The onus of verifying PwD certificate lies with the admitting institute. The GATE committee will not be responsible for any incorrect declaration of the PwD status of candidates.

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

### **(iv) Dyslexic Certificate**

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


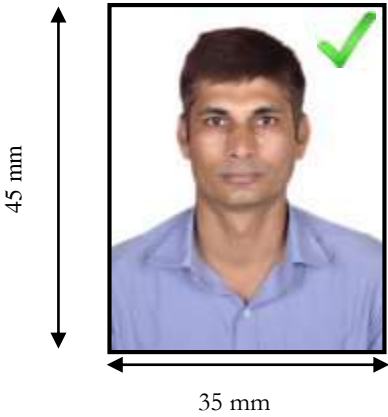


















## **4.4.7 Photograph and Signature Requirements**

The GATE 2020 application requires that your photograph and signature are to be uploaded electronically at GOAPS. Uploading photograph and signature that does not meet the specifications can result in the disqualification of the application without any refund of the application fee.

### **Photograph Requirements:**

- **Please upload only good quality photograph. The GATE scorecard will be printed with the photograph that you have submitted.**
- **The photograph must match with your appearance on the day of the examination.**
- A passport size (3.5 cm Width × 4.5 cm Height) photograph of the face of the candidate is required for the application form.
- The photograph must be in **COLOR** and taken **after 01 August 2019** in a professional studio. Photographs taken using a mobile phone and other self-composed portraits may result in rejection of the application.
- Request photo studio to provide the image of your photo in a JPEG format and also on a standard 3.5 cm × 4.5cm (Width × Height) print.
- **Maximum size for JPEG can be 480×640 in pixels (0.3 Mega pixel) (Request photo studio to reduce it to this resolution if it is higher).** Minimum size for JPEG should be 240×320 pixels.
- Background of the photograph must be **white** or a *light color*.

**Table 4.5 Sample Photographs**


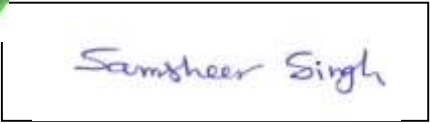

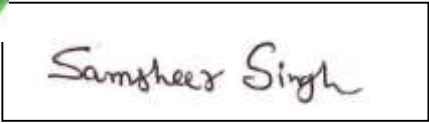

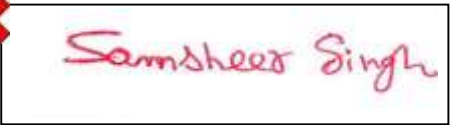

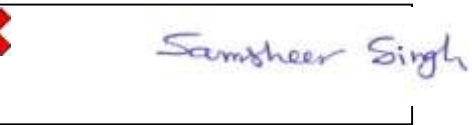



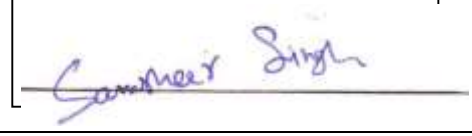



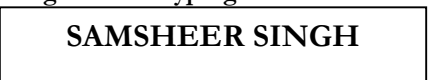
A: Sample Photographs: Acceptable		
		
B: Sample Photographs: Not Acceptable		
 	 	 
<p>Smaller in size (Not matching with a specified size of 35 mm width × 45 mm height)</p>	<p>Wearing colored glasses or sunglasses</p>	<p>Shadow on face</p>
 	 	 
<p>Improper background</p>	<p>Not facing the camera</p>	<p>Photo taken in dark background</p>
 	 	 
<p>Distorted Face</p>	<p>Face covered with cloth</p>	<p>Blurr image</p>

- The face should occupy at least 35% of the area of the photograph with a full-face view looking into the camera directly.
- The main features of the face must not be covered by hair of the head, any cloth or any shadow. Forehead, eyes, nose and chin should be clearly visible. The photograph should be without cap/ hat. The person in the photo must be facing the camera.
- If you normally wear spectacles, a photograph with glare on glasses is not acceptable in your photo. While you may wear spectacles for the photo shoot, **if the glare cannot be avoided, then remove the spectacles. In addition, you must not wear spectacles with dark or tinted glasses.**
- Poor quality of the photograph submitted will lead to rejection of your GATE application, without any refund of the application fee.
- [Table 4.5](#) shows the samples of acceptable good quality photographs and poor quality unacceptable photographs.

**Signature Specifications:**

- Please draw a rectangular box of size 2 cm × 7 cm (Height × Width) on an A4 white paper. Sign with black or dark blue ink pen within this box. The size of the signature (Height × Width) should be atleast 70~80% of the box size (preferred).

**Table 4.6 Sample Signatures**

Acceptable signatures	
 	 
Unacceptable signatures	
 <b>Signature in other than blue or black ink</b> 	 <b>Signature outside the rectangular box</b> 
 <b>Signature in smaller in size</b> 	 
 <b>Signature in dark background</b> 	 <b>Signature in typing</b> 

- The signature by any other person or in any other color (other than black and blue) will NOT be accepted.
- Get the digital image of the rectangular box (with your signature inside) scanned by using a professional scanner. Crop it to the border of the box. [Table 4.6](#) shows sample signatures which are acceptable and unacceptable.
- Only JPEG image format will be accepted.
- The maximum image size for the signature can be 160×560 in pixels.
- The minimum image size for the signature should be 80×280 in pixels.
- The signature must be signed only by the applicant and not by any other person.
- If the applicant's signature, at the time of examination, does not match the signature on the Admit Card, the applicant will be disqualified.

#### 4.4.8 Application Fee Payment Options

Details of the application fee are given in [Table 4.4](#). From the GOAPS portal, the candidate will be redirected to the payment gateway webpage, which provides the payment options. The fee can be paid with net-banking or debit/credit card.

The fee amount and bank charges will be shown to you, and you will have to confirm that the payment is for GATE 2020. Once you confirm and the payment is successful, you will be redirected back to the GOAPS website, from where you will be able to download the pdf copy of application form by clicking "Download Application Form" button.

If you have any difficulty (due to internet connection or power failure problems, for example), and you are not sure whether your payment has been processed or not, then please login back to GOAPS after some time and check the status of the payment.

You can also check the status of transaction from your bank account. In case, the fee amount has been debited (deducted) from your bank account, but GOAPS does not acknowledge any fee payment, then the money will be credited back to your account. However, this may take a week or more, after the closure of the application process.

In such a situation, you may initiate a fresh payment on GOAPS without waiting for the money to be credited back to your account. This will ensure that your application submission will be on time (within the deadline).

Before submitting the GATE 2020 Application Form, please ensure that all the details and all the necessary supporting documents are filled/uploaded and there is **NO ERROR** in that process. An application once submitted **CANNOT** be changed/rectified. **As a checklist the candidate MUST verify that he/she has filled in and uploaded the following information, whichever is applicable:**

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

- Address for Communication (including PIN code).
- Eligibility degree details (Roll No/ Registration No, College address, PIN code of college).
- Eligibility documents required to appear in GATE 2020 (e.g., degree certificate, Certificate from the Head of the Department/Institute, etc.).
- Category certificate (SC/ST/PwD) in case a concession in application fee is claimed.
- Good quality image of a recent photograph conforming to the requirements specified.
- Good quality image of signature conforming to the requirements specified.
- Details of the same valid ID Proof that will be carried to the examination hall.

**Important: It is essential that the candidate fills-in the details in GOAPS without ANY ERROR. The application is liable to be REJECTED if there is any error.**

#### **4.5. Application Scrutiny and Rectification**

All the applications submitted for GATE 2020 examination will be scrutinized for the accuracy of the data, which include uploaded supporting documents, clarity of the photograph and signature. If everything is found to be in order, the application will be accepted. Otherwise, defects in the application will be marked and intimated to the candidate for rectification, which needs to be carried out within a stipulated time. The status of the application and defects identified in the application will be intimated to the candidates by an e-mail and/or SMS. The current status of an application will be updated after its receipt and scrutiny by the respective zonal GATE offices. The status of your application can be checked anytime by logging into GOAPS.

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

#### **4.6. Admit Card**

The Admit Card for GATE 2020 will be available ONLY on GOAPS website. A candidate has to download his/her Admit Card from this website. The Admit Card would be available for download, from 3<sup>rd</sup> January 2020. Note that the Admit Cards will **NOT** be sent to the candidates by post/e-mail.

Candidates must bring a print-out of the downloaded Admit Card to the Examination for the verification **along with** the original and valid photo Identity Document (NO photocopy/scanned copy/NOT an expired document), which was specified during the filling up of the online application (for example: **Passport, PAN card, Voter ID, Aadhaar-UID, College ID, Employee ID and Driving License**)

The Admit Card is valid if and ONLY if the candidate's photograph and signature images are clear and legible. The photograph on the Admit Card and that in the valid photo identity document should match with the appearance of the candidate on the day of examination. To ensure this, print the



Admit Card on an A4 sized paper using a laser printer, preferably a color printer. **Both, the GATE 2020 Admit Card and the Original ID proof are essential for entry into the examination hall.**

## 5. GATE 2020 Examination Related Information

GATE 2020 examination will be conducted for 25 papers (subjects) as listed in Table 4.2. A candidate can appear for only one of the 25 GATE papers. The examination for all the papers will be conducted in an **ONLINE** Computer Based Test (CBT) mode where the candidates will be shown the questions on a computer screen.

A Virtual Scientific Calculator will be available on the computer screen during the examination. Candidates have to use the same during the examination. Personal calculators, wristwatches, mobile phones or any other electronic devices are **NOT allowed** in side the examination hall. Candidates should not bring any charts/tables/papers into the examination hall. GATE officials will not be responsible for the safe-keep of the candidates' personal belongings.

Scribble pads will be provided to the candidates for any rough work. The candidate has to write his/her name and registration number on the scribble pad before he/she starts using it. The scribble pad must be returned to the invigilator at the end of the examination.

*Syllabus for each of the papers (Appendix E), previous years GATE (model) question papers, and mock examination links along with virtual scientific calculator will be available on GATE 2020 website: <http://gate.iitd.ac.in>*

### 5.1. Examination Duration

All the papers of the GATE 2020 examination will be for **3 hours** duration and they consist of **65** questions for a total of **100 marks**. Since the examination is an ONLINE computer based test, at the end of the stipulated time (3-hours), computer will automatically close the screen inhibiting any further action.

Candidates will be permitted to occupy their allotted seats **40 minutes** before the scheduled start of the examination. Candidates can login and start reading the instructions 20 minutes before the start of examination. **Candidates will NOT be permitted to enter the examination hall after 10:00 hours in the forenoon session and after 15:00 hours in the afternoon session. Candidates will NOT be permitted to leave the examination hall before the end of the examination.**

### 5.2. GATE 2020 Question Papers

#### 5.2.1 Pattern of Questions

GATE 2020 would contain questions of two different types in all the papers:

(i) **Multiple Choice Questions** (MCQ) carrying **1 or 2** marks each in all the papers and sections. These questions are objective in nature, and each will have a choice of four answers, out of which the candidate has to select (mark) the correct answer.

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



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

Example

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

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

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

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

### 5.3. Marking Scheme – Distribution of Marks and Questions

#### 5.3.1 General Aptitude (GA) Questions

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

#### 5.3.2 Question Papers other than GG, XE and XL

These papers would contain **25** questions carrying **1-mark** each (sub-total **25 marks**) and **30** questions carrying **2-marks** each (sub-total **60 marks**) consisting of both the MCQ and NAT Questions.

#### 5.3.3 GG (Geology and Geophysics) Paper

Apart from the General Aptitude (GA) section, the GG question paper consists of two parts: **Part A** and **Part B**. **Part A** is compulsory for all the candidates. **Part B** contains two sections: Section 1 (Geology) and Section 2 (Geophysics). Candidates will have to attempt questions in **Part A** and questions in either Section 1 or Section 2 of **Part B**.

**Part A** consists of **25** questions carrying **1-mark** each (sub-total **25 marks** and some of these may be numerical answer type questions). Either section of **Part B** (Section 1 and Section 2) consists of **30** questions carrying **2-marks** each (sub-total **60 marks** and some of these may be numerical answer type questions).

#### 5.3.4 XE Paper (Engineering Sciences)

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

- **GA – General Aptitude** carrying a total of **15 marks**.
- **Section A– Engineering Mathematics (Compulsory):** This section contains **11** questions carrying a total of **15 marks**: **7** questions carrying **1-mark** each (sub-total **7 marks**), and **4** questions carrying **2-marks** each (sub-total **8 marks**). Some questions may be of numerical answer type.

- **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 questions may be of numerical answer type.

### 5.3.5 XL Paper (Life Sciences)

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

- **GA – General Aptitude** carrying a total of **15 marks**.
- **Section P– Chemistry (Compulsory):** This section contains **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 questions may be of numerical answer type.
- **Any two of XL Sections Q to U:** The choice of two sections from Q to U can be made during the examination after viewing the questions. Only TWO optional sections can be answered at a time. A candidate wishing to change midway of the examination to another optional section must first choose to deselect one of the previously chosen optional sections (Q to U). Each of the optional sections of the XL paper (Sections Q through U) contains **20** questions carrying a total of **30 marks: 10** questions carrying **1-mark** each (sub-total **10 marks**) and **10** questions carrying **2-marks** each (sub-total **20 marks**).Some questions may be of numerical answer type.

## 6. Post-Examination Related Information

Post examination events are as follows:

1. After the GATE 2020 examinations, candidates' responses will be available at GOAPS, which can be downloaded.
2. Answer keys for various GATE 2020 papers will be displayed in GATE 2020 website.
3. Candidates may submit their contests on the answer keys provided for a very limited time period against a payment.
4. Evaluation of examination papers will be finalized and GATE results (Score) will be announced.
5. GATE 2020 scorecard will be made available for the qualified candidates from GOAPS.

### 6.1. GATE Score

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

Thus, raw marks (for single session papers) or normalized marks (for multi-session papers) will be used for computing the GATE Score, based on the qualifying marks.

### 6.1.1 Calculation of Normalized Marks for Multi-session Papers

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

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

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

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

where

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

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

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

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

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

### 6.1.2 Calculation of GATE Score for All Papers

For all papers for which there is only one session, actual marks obtained by the candidates will be used for calculating the GATE 2020 Score. For papers in multi-sessions, normalized marks will be calculated corresponding to the raw marks obtained by a candidate and the GATE 2020 Score will be calculated based on the normalized marks.

The GATE 2020 score will be computed using the formula given below.

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

where

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

$M_q$ : is the qualifying marks for general category candidate in the paper

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

$S_q$ : 350, is the score assigned to  $M_q$

$S_t$ : 900, is the score assigned to  $\bar{M}_t$

In the GATE 2020 the qualifying marks ( $M_q$ ) for general category student in each subject will be 25 marks (out of 100) or  $\mu + \sigma$ , whichever is larger. Here  $\mu$  is the mean and  $\sigma$  is the standard deviation of marks of all the candidates who appeared in the paper.

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

The GATE 2020 Committee has the authority to decide the qualifying mark/score for each GATE paper. In case of any claim or dispute with respect to GATE 2020 examination or score, the Courts and Tribunals in Delhi alone will have the exclusive jurisdiction to entertain and settle them.

## 6.2. GATE 2020 Results

GATE 2020 results will be announced on the 16<sup>th</sup> March 2020 and will be available on the GOAPS Website. GATE 2020 score is valid for **THREE YEARS** from the date of announcement of the results.

## 6.3. GATE 2020 Scorecard

After the declaration of results, the qualified candidates can download their GATE 2020 Scorecards (for the paper which candidates have taken the examination). The GATE 2020 scorecards can be downloaded between 20 March 2020 to 31 May 2020 from the GOAPS portal. It is highly recommended that a softcopy of the scorecard is safely stored by the candidate for all the futuristic uses.

In case, a GATE qualified candidate requires the soft copy of his/her GATE Scorecard after 31 May 2020 and till 31 December 2020, should pay a fee of ₹ 500 (Rupees five hundred only) for obtaining the same.

**There is no provision for the issue of hard copies of the GATE Scorecards.**

## 7. GATE 2020 at International Centres

GATE 2020 examinations will be conducted in the following cities outside India: Addis Ababa (Ethiopia), Colombo (Sri Lanka), Dhaka (Bangladesh), Dubai (UAE), Kathmandu (Nepal) and Singapore. The application fee for Dubai (UAE) and Singapore centres is US\$ 100; and for the remaining it is US\$ 50. Candidates of any nationality can opt for international centres.

- Candidates who have obtained/are pursuing their qualifying degree from countries other than India: (i) must have completed or are in the final year of their Bachelor's degree (duration: at least 4 years) in Engineering/Technology or; (ii) must have completed or are in the final year of their Post Graduate (Master's) degree (duration: at least 2 years) in any relevant science subject.

- For candidates at international centres, ONLY a valid Passport/Government issued ID/College ID/Employee ID will be accepted as the recognized identification.
- For Foreign nationals, SC/ST/PwD categories are NOT APPLICABLE.
- The session timing at GATE International Centres will be as per their local time and it will be notified well in advance.
- The application procedure remains same for Foreign nationals as that of Indian nationals.
- The candidates opting for international examination centres will be contacted only through their e-mail. However, mobile numbers can be used only when the GATE 2020 Organising Institute intends to communicate an important information to them.

## 8. Frequently Asked Questions (FAQs)

### 8.1. Application Process

#### **Can I appear in any of the GATE 2020 papers?**

The candidate is expected to appear in a paper appropriate to the discipline of his/her qualifying degree. The candidate can also choose any other papers of GATE 2020, however, it is better to choose a paper in line with the eligibility criteria of the institutions/organizations in which he/she wishes to seek admission/job.

#### **How do I apply ONLINE?**

Refer to [Section 4.4.2](#) given in the GATE 2020 Brochure and by visiting the website <http://gate.iitd.ac.in>

#### **Can I use one e-mail address to fill multiple application forms?**

NO. One e-mail address can be used to submit only ONE application form. Candidates are discouraged to fill multiple application forms using different e-mail addresses.

#### **Why should I choose three examination cities?**

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

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

Please login to the GOAPS website again and continue the application process.

**Only SC/ST/PwD candidates have been asked to upload the category certificates. What about the OBC (non-creamy layer) candidates? Do they have to upload the category certificate too?**

NO. Category certificate is required only for Indian nationals (appearing from exam centres within India), who wishes to avail a concession in application fee. As far as the GATE 2020 examination is concerned, only SC/ST/PwD candidates and all women candidates are eligible for application fee concession.

**How do I make the fee payment for GATE 2020 examination?**

There is a link to the payment gateway from the application portal. The candidate can opt for any of the payment options listed over there. The additional charges such as service charges, processing fees or bank charges, have to be borne by the candidate.

**What is the fee for candidates with foreign nationality?**

For the candidates with Foreign nationality, who wish to appear for GATE 2020 examination, the application fee is as follows:

Examination Centres	On or before 24 <sup>th</sup> Sept. 2019	During the Extended Period
Centres in India	₹ 1500	₹ 2000
Addis Ababa, Colombo, Dhaka and Kathmandu	US\$ 50	US\$ 70
Dubai and Singapore	US\$ 100	US\$ 120

**What is the fee for candidates with Indian nationality appearing at International centres?**

For the candidates with Indian nationality, who wish to appear for GATE 2020 examination, the application fee (irrespective of their category and gender) is as follows:

Examination Centres	On or before 24 <sup>th</sup> Sept. 2019	During the Extended Period
Addis Ababa, Colombo, Dhaka and Kathmandu	US\$ 50	US\$ 70
Dubai and Singapore	US\$ 100	US\$ 120

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

When you can get back online, login back to GOAPS website and check the status of the payment. If the payment was received by GATE, you can continue the process of printing the application form.

If the payment was not received by GATE, you can also check the status of transaction from your bank account. In case, the fee amount has been debited (deducted) from your bank account, but GOAPS does not acknowledge any fee payment, then the money will be credited back to your account. However, this may take a week or more, after the closure of the application process.



In such a situation, you may initiate a fresh payment on GOAPS without waiting for the money to be credited back to your account. This will ensure that your application submission will be on time (within the deadline).

**My net banking account has been debited more than once. How do I get the money back?**

Any unaccounted or excess money that was received on behalf of GATE 2020 from this account, will automatically be returned (credited) to the same bank account. However, this may take a week or more, after the closure of the application process.

**My bank account has been debited (money taken out), but GOAPS website says that the payment has not been received. What do I do?**

Please login back to GOAPS **after some time** and check the status of the payment. Even then, if GOAPS does not acknowledge any fee payment, the money will be credited back to your account. However, this may take a week or more, after the closure of the application process. In such a situation, you may initiate a fresh payment on GOAPS without waiting for the money to be credited back to your account. This will ensure that your application submission will be on time (within the deadline). Finally, you will be charged only once. Any excess/unaccounted debits will be returned back to you.

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

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

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

You can check the status of your application by logging into GOAPS website.

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

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

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

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

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

YES, the application will be rejected.

### **Which Identity Document (ID) will be accepted in the application form?**

For Indian candidates, the following identification documents/cards will be accepted: **Passport, PAN Card, Voter ID, Aadhaar-UID, College ID, Employee ID and Driving License**. For International candidates, **ONLY valid Passport/Government issued ID/College ID/Employee ID** will be accepted as the recognized identification.

### **If I am in the final year of my qualifying degree program, what certificate do I upload?**

If a candidate is in the final year of the qualifying degree program, a **Certificate from the Head of the Department/Institute** (in the format given in [Appendix A](#)), must be uploaded.

### **If I have completed the degree in 2019, but my institute has still not provided me with the degree certificate/provisional certificate, which document should I upload as eligibility certificate?**

In case, the degree certificate/provisional certificate has not been issued at the time of application, final year marksheet (of any one semester) must be uploaded as eligibility document.

### **I have backlogs/arrears during the qualifying degree program, due to which I did not complete the program. I am currently not studying in the college and therefore cannot get duly signed Certificate from the Head of the Department/Institute. Which document should I upload while filling the application form?**

If you cannot get a duly signed Certificate from the Head of the Department/Institute, you should submit final year marksheet (of any one semester), even if there are backlogs/arrears in some subjects.

### **Is the downloaded marksheet (from internet) acceptable as an eligibility document?**

Yes, internet downloaded final year marksheet (of any one semester), which is **digitally signed** or duly signed with seal by competent authority (Registrar, Controller of Examination etc.) **ONLY**, is acceptable.

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

The cut-off score and fee for EWS candidates will be **SAME** as General candidates.

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

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

### **Do I have to upload my EWS certificate during the application process?**

**No.** Since, the **“GATE CUT-OFF SCORE”** for General and General-EWS categories are same, you need not upload any EWS certificate.

## 8.2. Admit Card

### When will I receive my Admit Card?

Admit Card can ONLY be downloaded from the GOAPS website from 3<sup>rd</sup> January 2020. Admit Cards will NOT be sent by post or as an e-mail attachment.

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

**NO.** Candidates must bring a print-out of the downloaded Admit Card to the Examination for the verification **along with** the original and valid photo Identity Document (NO photocopy/scanned copy/NOT an expired document), which was specified during the filling up of the online application. **For Indian candidates**, only following identification cards will be accepted: Passport, PAN card, Voter ID, Aadhaar-UID, College ID, Employee ID and Driving License. **For International candidates**, ONLY a valid Passport/Government issued ID/College ID/Employee ID will be accepted as the recognized identification.

The Admit Card is valid if and ONLY if the candidate's photograph and signature images are clear and legible. The photograph on the Admit Card and that in the valid photo identity document should match with the appearance of the candidate on the day of examination.

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

**NO.** Hard copy (preferably printed in color) of the Admit Card must be brought to the examination centre along with at least one original (not photocopied/scanned copy) and valid (not expired) **Identity Document (ID)**, which was specified during the filling up of the online application.

## 8.3. GATE 2020 Examination

### For how many GATE papers can I apply?

A candidate can apply for only ONE of the 25 papers listed in the GATE INFORMATION BROCHURE or GATE website. The choice of the appropriate paper is the responsibility of the candidate. Some guidelines in this respect are suggested below:

- The candidate is expected to appear in a paper appropriate to the discipline of his/her qualifying degree.
- The candidate is, however, free to choose any other paper according to his/her admission plan, keeping in mind the eligibility criteria of the institutions in which he/she wishes to seek admission.

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

**NO.** Requests for the change of GATE Examination paper after the submission of Application Form WILL NOT be permitted.

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

YES. ONLY after the last date for application submission, a request for the change of examination city will be entertained **against payment**. A specific time period for the same will be notified in the GATE 2020 website.

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

YES. Category change request will be entertained till November 4, 2019. Any request after this date won't be considered.

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

A scribble pad will be provided to the candidate that can be used to do the rough work. The candidate has to return the scribble pad after the examination.

**Am I allowed to leave the examination hall during the examination?**

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

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

Only Admit Card, Identification Card and a pen is permitted to be taken inside the examination hall. Mobile phones, physical calculators, wristwatches, or any other electronic items are NOT permitted inside the examination hall. If a candidate brings any of these items, they have to be kept outside the examination hall at the candidate's own risk. If the candidate is found to be in possession of these items (even if not using them), he/she will be disqualified and the result will not be declared for the candidate.

**Can I use a physical calculator during the examination?**

NO. During the online GATE 2020 examination, all candidates will be provided with a virtual scientific calculator which has to be used to answer the questions. Mobile phones, physical calculators, wristwatches, or any other electronic items are NOT permitted inside the examination hall.

**Will there be any arrangement at the examination centre for the safe keeping of my personal items such as my mobile phone?**

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

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

Such cases will naturally constitute violation of GATE 2020 code of conduct (as given in [Appendix D](#)) and will lead to disqualification of the candidature.

## **Is there a separate rank/paper for Geology and Geophysics candidates in GATE 2020?**

There will be same GG paper for all Geology and Geophysics candidates. However, separate scores and ranks will be provided to Geology and Geophysics candidates based on the Part B section in GG paper (keeping the GG paper pattern as it is).

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

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

## **8.4. PwD and Dyslexic Candidates**

### **What are the details of the guidelines that will be followed about PwD candidates writing GATE 2020 examination?**

GATE 2020 will follow the revised guidelines as mentioned in the government regulations ([Appendix E](#)). Please refer to:

[http://disabilityaffairs.gov.in/upload/uploadfiles/files/Guidelines-29\\_08\\_2018%20\(1\).pdf](http://disabilityaffairs.gov.in/upload/uploadfiles/files/Guidelines-29_08_2018%20(1).pdf)

### **Will the facility of scribe and/or compensatory (extra) time be given to all PwD candidates?**

The facility of scribe is meant for only those PwD candidates who have physical limitation to write including that of speed. Candidates can bring their own scribe or can request GATE authorities to arrange scribe. The compensatory (extra) time of one additional hour for a 3 hours exam would be applicable to such candidates.

### **Will there be a “magnified question paper” for visually challenged PwD candidates?**

YES. Once you reach the examination hall, please contact the GATE Institute Representative through the invigilator in your examination hall and he/she will do the needful.

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

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

### **Is there a provision of getting compensatory (extra) time for a PwD/dyslexic candidate without opting for a scribe?**

Candidates with certain disabilities, which limits the speed of writing, may ask for compensatory (extra) time of one hour, if requested well in advance. GATE authorities will then take a final decision whether extra time will be permitted or not.

## 9. Contact Information

GATE is jointly administered and conducted by the Indian Institute of Science and seven Indian Institutes of Technology.

[Table 9.1](#) gives the details of each Zonal Office. Each of the institutes administer a zone and caters to a list of examination cities that fall under that zone ([Table 4.3](#)). Candidates are assigned a zone at the time of application, based on the first choice of city. Candidates must note this zone number for future references. Any queries regarding the application, examination centre, Admit Card, and result are handled by the GATE 2020 Organising Institute.

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

**Table 9.1 Contact details for Zonal GATE Offices**

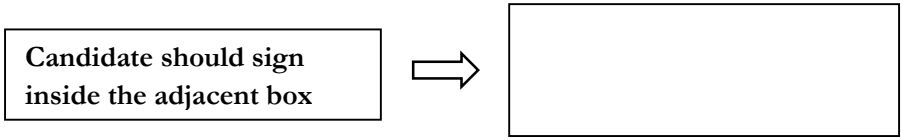
Zone	Contact Address	Phone Number	e-mail Id
1	Chairman, GATE Indian Institute of Science, Bengaluru 560 012	080-22932392 080-23601227	<a href="mailto:gate@gate.iisc.ac.in">gate@gate.iisc.ac.in</a>
2	Chairman, GATE Indian Institute of Technology Bombay, Powai, Mumbai 400 076	022-25767068	<a href="mailto:gateoffice@iitb.ac.in">gateoffice@iitb.ac.in</a>
3	Chairman, GATE Indian Institute of Technology Delhi, Hauz Khas, New Delhi 110016	011-26591749 011-26596137	<a href="mailto:chrgate@admin.iitd.ac.in">chrgate@admin.iitd.ac.in</a>
4	Chairman, GATE Indian Institute of Technology Guwahati, Guwahati 781 039	0361-2582751 0361-2582755	<a href="mailto:gate@iitg.ac.in">gate@iitg.ac.in</a>
5	Chairman, GATE Indian Institute of Technology Kanpur, Kanpur 208 016	0512-2597412	<a href="mailto:gate@iitk.ac.in">gate@iitk.ac.in</a>
6	Chairman, GATE Indian Institute of Technology Kharagpur, Kharagpur 721 302	03222-282091 03222-282095	<a href="mailto:gate@adm.iitkgp.ac.in">gate@adm.iitkgp.ac.in</a>
7	Chairman, GATE Indian Institute of Technology Madras, Chennai 600 036	044-22578200	<a href="mailto:gate@iitm.ac.in">gate@iitm.ac.in</a>
8	Chairman, GATE Indian Institute of Technology Roorkee, Roorkee 247 667	01332-284531	<a href="mailto:gate@iitr.ac.in">gate@iitr.ac.in</a>

**Appendix A: Certificate from Head of the Department/ Institute**  
**Certificate from Head of the Department/Institute**

**(Eligibility Document for GATE 2020 Application)**

This is to certify that Mr. / Ms. ....  
S/o or D/o ..... is a student enrolled  
in the department of ..... at the Institute/  
College..... for the program as per the  
details given below:

**Paste Recent  
Photo of the  
Candidate  
(Passport Size)**



**Do not attest  
Do not sign on  
photo**

1. Roll No/ Registration No./ Student ID : .....
2. The student is in the final year of ..... (B.E. / B.Tech/ B.S./ B.Sc Research/  
M.Sc/ Integrated M.Sc/B.Arch/ M.C.A).      OR
3. The student is in the pre-final year of ..... (ME/ M.Tech/ Dual Degree/ Integrated  
M.E./ M.Tech) .
4. Duration of the program which the student is studying :..... Years
5. The student is pursuing the undergraduate program on lateral entry: 1.  Yes 2.  No

Signature of the Candidate with date:

Signature of the Head of the Department / Institute with seal

Date:

Note: Without signature of the Head of the Department/Institute & seal, the certificate is not valid.

## Appendix B: Qualifying Disciplines

### Qualifying Disciplines for Eligibility Degrees

Disciplines: Engineering/Technology		
Aeronautical Engg.	Electrical Instrumentation & Control Engg.	Manufacturing Engg.
Aerospace Engg	Electrical and Mechanical Engg.	Manufacturing Science & Engg.
Aircraft Maintenance Engg	Electrical and Power Engineering	Manufacturing Technology
Agricultural Engg.	Electro-Chemical Engg.	Marine Engg. / Technology
Agricultural Technology	Electronics Engg.	Material Science and Engg. / Technology
Architecture/ Architectural Engg.	Electronics & Biomedical Engg.	Mechanical Engg.
Architecture & Interior Design / Decoration	Electronics Communication & Instrumentation	Mechatronics
Automation & Robotics	Electronics & Computer Engg.	Mechatronics & Automation Engg.
Automobile Engg.	Electronics & Communication	Medical Electronics / Engg.
Automobile Maintenance Engg.	Electronics & Telecommunication	Medical Instrumentation
Biochemical Engg.	Electronics & Power	Metallurgical Engg.
Biomedical Engg.	Energy Engg.	Military Engg.
Biomedical Instrumentation	Energy & Environmental Engg.	Mineral Engg. / Mineral Dressing
Biotechnology	Environmental Engg.	Mining Engg. / Technology, Mining & Machinery
Cement & Ceramic Technology	Environmental Science & Technology	Nano Technology & Robotics
Ceramic Engg. & Technology	Environmental Planning	Naval Architecture / Marine Engg.
Ceramic & Glass Technology	Environment & Pollution Control	Oil Technology
Chemical Engg.	Fashion Technology / Fashion & Apparel Technology	Optics & Optoelectronics
Chemical Technology	Fibres & Textiles Processing Technology	Paint Technology
Civil Engg	Fire Engg. / Technology & Safety	Petro-Chemical Engg.
Civil & Environmental Engg	Food Engg. & Technology.	Petroleum Engg. / Technology
Civil & Structural Engg.	Food Processing Engg / Processing & Preservation Engg.	Petroleum Refinery Engg.
Civil & Construction Engg.	Industrial Technology	Planning ( Environmental / Infrastructure / Urban & Regional/ Urban Regeneration)
Civil & Infrastructure Engg.		
Civil & Water Resource Management	Industrial Engg.	Plastic Engg. / Technology
Computer Engg.	Industrial Management	Polymer Engg. / Science /Technology
Computer Science & Engg.	Industrial Metallurgy	Polymer Science & Chemical Technology
Computer Science & Technology	Information & Communication Technology	Power Electronics / Power Electronics Engg.
Computer Science & Information Technology	Information Engineering	Power Engg.
Communication Engg.	Information Technology	Printing & Packing Technology
Control & Instrumentation	Instrumentation & Process Control/ Engineering	Production & Industrial Engg.
Construction Engg. & Management	Instrumentation Engg. / Technology	Renewable Energy
Dairy Engg. / Technology	Instrumentation & Process Control	Robotics & Automation
Electrical Engg.	Leather / Foot Wear Technology	Rubber Technology
Electrical and Electronics Engg.	Machine Engg.	Telecommunication Engg.
Electrical and Instrumentation Engg.	Man-Made Fibre / Textile Technology	Textile Engg. / Technology



<b>Disciplines: Science</b>		
Agricultural Science	Engineering Physics	Nano Science & Technology
Applied Electronics	Geology / Geophysics	Nuclear Science & Technology
Applied Mathematics	Geo Informatics	Nuclear Physics
Applied Mechanics	Industrial Chemistry	Operations Research
Applied Physics	Information Science	Pharmaceuticals Chemistry & Technology
Biochemistry	Life Sciences ( Botany)	Pharmaceutical Sciences / Pharmacy
Bio-Sciences	Life Sciences ( Zoology)	Physics
Chemistry	Life Science / Veterinary / Animal Science	Radio Physics
Computer Applications	Materials Science	Radio Physics & Electronics
Earth Sciences	Mathematics	Statistics
Electronics	Mathematics & Computing	Textile Chemistry
Electronics & Computer Science	Microbiology	Urban Transportation Planning & Management

## Appendix C

### Authorities Empowered to Issue SC/ST Certificates

- District Magistrate/Additional District Magistrate/Collector/Deputy Collector/Deputy Commissioner/Additional Deputy Commissioner/1st Class Stipendiary Magistrate/City Magistrate/Sub-Divisional Magistrate/Taluk Magistrate/Executive Magistrate/Extra Assistant Commissioner.
- Chief Presidency Magistrate/Additional Chief Presidency Magistrate/Presidency Magistrate
- Revenue Officer not below the rank of Tahsildar
- Sub-Divisional Officer of the area where the Candidate and/or her/his family normally resides
- Administrator/Secretary to Administrator/Development Officer (Lakshadweep Islands)

Certificate issued by any other official will NOT be accepted.

### Person with Disability (PwD) Category

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

### Authorities empowered to issue Dyslexic Certificate

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

1. Dyslexia Trust of Kolkata, Divya Jalan, Aruna Bhaskar 3, Dover Park, Kolkata – 700019
2. Dyslexia Association Of Andhra Pradesh (DAAP), 3-4-494/1,1st Floor, Macherla Gastrology Hospital, Reddy College Road, Barkatpura, Hyderabad, Telangana, 500027
3. Madras Dyslexia Association, 94 Park View, 1st Floor, G.N. Chetty Road, T. Nagar, Chennai – 600017
4. Maharashtra Dyslexia Association, 003, Amit Park Bldg, L J Road, Deonar, Mumbai 400088
5. The Dyslexia Association of India, MZ-47, The Center Stage Mall, Plot No 01, Block L, Sector 18, Noida, 201303

## **Appendix D: Code of Conduct for GATE 2020 Examination**

### **CODE OF CONDUCT**

**All the candidates appearing for GATE 2020 Examination must comply strictly with the following Rules and Regulations:**

- Candidates appearing for GATE 2020 examination must carry Admit Card and original valid photo-identity proof inside the examination hall.
- Scribble pads will be provided to the candidates in the examination hall by the invigilators. The same should be used for all rough work. Candidates should write their name and registration number on the scribble pads. The scribble pads must be returned to the invigilators after the end of the examination.
- Carrying mobile phones (even in the switched-off mode), wristwatches and calculators inside the examination hall is strictly prohibited.
- Carrying of any other electronic devices that can be used for communication or for any other purpose, and printed or hand-written textual materials, inside the examination hall is strictly prohibited.
- All means of communication (verbal or otherwise) among the candidates inside the examination hall are strictly prohibited.
- Candidates should not tamper with the computer and the related hardware provided in the examination hall. Candidates found to have tampered with these willfully, will have their candidature cancelled summarily. In addition, appropriate legal action will be initiated against such candidates.

The GATE 2020 candidature of candidates found using unfair means and not in line with the code and ethics of the GATE examination may be cancelled. Their examination will not be evaluated, even if they may have been allowed to complete their examination. In addition, appropriate legal action may be initiated against all such candidates.

## Appendix E: Syllabus Content

### GA: GENERAL APTITUDE (COMMON TO ALL PAPERS)

**Verbal Ability:** English grammar, sentence completion, verbal analogies, word groups, instructions, critical reasoning and verbal deduction.

**Numerical Ability:** Numerical computation, numerical estimation, numerical reasoning and data interpretation.

#### Sample Questions

##### *Verbal Ability*

Choose the appropriate answer to complete the following sentence:

To those of us who had always thought him timid, his \_\_\_\_\_ came as a surprise.

- (A) intrepidity (B) inevitability (C) inability (D) inertness

Choose the appropriate answer to complete the following sentence:

Medicine is to illness as law is to \_\_\_\_\_

- (A) discipline (B) anarchy (C) treason (D) etiquette

Read the following paragraph:

“The ordinary form of mercury thermometer is used for temperature ranging from  $-40^{\circ}\text{F}$  to  $500^{\circ}\text{F}$ . For measuring temperature below  $-40^{\circ}\text{F}$ , thermometers filled with alcohol are used. These are, however, not satisfactory for use in high temperatures. When a mercury thermometer is used for temperature above  $500^{\circ}\text{F}$ , the space above the mercury is filled with some inert gas, usually nitrogen or carbon dioxide, placed in the thermometer under pressure. As the mercury rises, the gas pressure is increased, so that it is possible to use these thermometers for temperatures as high as  $1000^{\circ}\text{F}$ .”

With what, besides mercury, would a thermometer be filled if it was designed to be used for measuring temperature of about  $500^{\circ}\text{F}$ ?

- (A) Pyrometer (B) Inert gas (C) Iron and brass (D) Gas

The cost of manufacturing tractors in Korea is twenty percent less than the cost of manufacturing tractors in Germany. Even after transportation fees and import taxes are added, it is still cheaper to import tractors from Korea to Germany than to produce tractors in Germany.

Which of the following assertions is best supported by the above information?

- (A) Labour costs in Korea are twenty percent below those in Germany.  
(B) Importing tractors into Germany will eliminate twenty percent of the manufacturing jobs in Germany.  
(C) The costs of transporting a tractor from Korea to Germany is more than twenty percent of the cost of manufacturing the tractor in Korea.  
(D) The import taxes on a tractor imported from Korea to Germany is less than twenty percent of the cost of manufacturing the tractor in Germany.

##### *Numerical Ability*

In a survey,  $\frac{3}{16}$  of the people surveyed told that they preferred to use public transport while commuting daily to office.  $\frac{5}{8}$  of the people surveyed told that they preferred to use their own vehicles. The remaining 75 respondents said that they had no clear preference. How many people preferred to use public transport?

- (A) 75 (B) 100 (C) 125 (D) 133

## **AE: Aerospace Engineering**

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

### Section 1: Engineering Mathematics

Core Topics:

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

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

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

**Special Topics: Fourier Series, Laplace Transforms, Numerical methods for linear and nonlinear algebraic equations, Numerical integration and differentiation.**

### Section 2: Flight Mechanics

Core Topics:

**Basics:** Atmosphere: Properties, standard atmosphere. Classification of aircraft. Airplane (fixed wing aircraft) configuration and various parts.

**Airplane performance:** Pressure altitude; equivalent, calibrated, indicated air speeds; Primary flight instruments: Altimeter, ASI, VSI, Turn-bank indicator. Drag polar; takeoff and landing; steady climb & descent, absolute and service ceiling; cruise, cruise climb, endurance or loiter; load factor, turning flight, V-n diagram; Winds: head, tail & cross winds.

**Static stability:** Angle of attack, sideslip; roll, pitch & yaw controls; longitudinal stick fixed & free stability, horizontal tail position and size; directional stability, vertical tail position and size; dihedral stability. Wing dihedral, sweep & position; hinge moments, stick forces.

**Special Topics: Dynamic stability: Euler angles; Equations of motion; aerodynamic forces and moments, stability & control derivatives; 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.

**Special Topics: Orbit transfer, in-plane and out-of-plane.**

### Section 4: Aerodynamics

Core Topics:

**Basic Fluid Mechanics:** Conservation laws: Mass, momentum (Integral and differential form);

**Potential flow theory:** sources, sinks, doublets, line vortex and their superposition; Viscosity, Reynold's number.

**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, Conservation equations; One dimensional compressible flows, Fanno flow, Rayleigh flow; Isentropic flows, normal and oblique shocks, Prandtl-Meyer flow; Flow through nozzles and diffusers.

**Special Topics:** Elementary ideas of viscous flows including boundary layers; Wind Tunnel Testing: Measurement and visualization techniques.

## Section 5: Structures

Core Topics:

**Strength of Materials:** States of stress and strain. Stress and strain transformation. 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. Analysis of statically determinate and indeterminate trusses and beams. Elastic flexural buckling of columns.

**Flight vehicle structures:** Characteristics of aircraft structures and materials. Torsion, bending and flexural 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 and heat transfer and combustion thermochemistry.

**Thermodynamics of aircraft engines:** Thrust, efficiency and engine performance of turbojet, turboprop, turbo shaft, turbofan and ramjet engines, thrust augmentation of turbojets and turbofan engines. Aerothermodynamics of non-rotating propulsion components such as intakes, combustor and nozzle.

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

**Axial turbines:** Axial turbine stage efficiency.

**Centrifugal compressor:** Centrifugal compressor stage dynamics, inducer, impeller and diffuser.

**Rocket propulsion:** Thrust equation and specific impulse, vehicle acceleration, drag, gravity losses, multi-staging of rockets. Classification of chemical rockets, performance of solid and liquid propellant rockets.

**No Special Topics**

# AG: Agricultural 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; tests for convergence; Fourier series, Taylor 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 Ordinary Differential Equations (ODE); Higher order linear ODEs with constant coefficients; Cauchy's and Euler's equations; Laplace transforms; 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; tests of significance, analysis of variance (ANOVA).

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

## 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, torque, speed, displacement and acceleration on machine elements.

**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, threshing and transport; testing of agricultural machinery and equipment; calculation of performance parameters - field capacity, efficiency, application rate and losses; cost analysis of implements and tractors.

## Section 3: Farm Power

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

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

**Tractors and Powertillers:** Type, selection, maintenance and repair of tractors and powertillers; 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; mechanical steering and hydraulic control systems used in tractors; tractor tests and performance.

Human engineering and safety in design of tractor and agricultural implements.

## Section 4: Soil and Water Conservation Engineering

**Fluid Mechanics:** Ideal and real fluids, properties of fluids; hydrostatic pressure and its measurement; hydrostatic forces on plane and curved surface; continuity equation; Bernoulli's theorem; laminar and turbulent flow in pipes, Darcy- Weisbach and Hazen-Williams equations, Moody's diagram; flow through orifices and notches; flow in open channels.

**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.

**Hydrology:** Hydrological cycle and components; meteorological parameters, their measurement and analysis of precipitation data; runoff estimation; hydrograph analysis, unit hydrograph theory and application; stream flow measurement; flood routing, hydrological reservoir and channel routing.

**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; the dolomite traversing; contouring; computation of areas and volume.

**Soil and Water Erosion:** Mechanics of soil erosion, soil erosion types, wind and water erosion, 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; land use capability classification; rain water harvesting structures, 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.

**Groundwater Hydrology:** Groundwater occurrence; Darcy's Law, steady flow in confined and unconfined aquifers, evaluation of aquifer properties; groundwater recharge.

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

#### Section 6: Agricultural Processing Engineering

**Drying:** Psychrometry – properties of air-vapors mixture; concentration and drying of liquid foods – evaporators, tray, drum and spray dryers; hydrothermal treatment; drying and milling of cereals, pulses and oilseeds.

**Size Reduction and Conveying:** Mechanics and energy requirement in size reduction of granular solids; 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 grain cleaners; centrifugal separation of solids, liquids and gases.

**Processing and By-product Utilization:** Processing of seeds, spices, fruits and vegetables; By-product utilization from processing industries.

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

#### 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**

### Section 1: Architecture and Design

Visual composition in 2D and 3D; Principles of Art and Architecture; Organization of space; Architectural Graphics; Computer Graphics– concepts of CAD, BIM, 3D modeling and Architectural rendition; Programming languages and automation. Anthropometrics; Planning and design considerations for different building types; Site planning; Circulation- horizontal and vertical; Barrier free design; Space Standards; Building Codes; National Building Code.

Elements, construction, architectural styles and examples of different periods of Indian and Western History of Architecture; Oriental, Vernacular and Traditional architecture; Architectural developments since Industrial Revolution; Influence of modern art on architecture; Art nouveau, Eclecticism, International styles, Post Modernism, Deconstruction in architecture; Recent trends in Contemporary Architecture; Works of renowned national and international architects.

### Section 2: Building Materials, Construction and Management

Behavioral characteristics and applications of different building materials viz. mud, timber, bamboo, brick, concrete, steel, glass, FRP, AAC, different polymers, composites.

Building construction techniques, methods and details; Building systems and prefabrication of building elements; Principles of Modular Coordination; Estimation, specification, valuation, professional practice; Construction planning and equipments; Project management techniques e.g. PERT, CPM etc.



### Section 3: Building and Structures

Principles of strength of materials; Design of structural elements in wood, steel and RCC; Elastic and Limit State design; Structural systems in RCC and Steel; Form and Structure; Principles of Pre-stressing; High Rise and Long Span structures, gravity and lateral load resisting systems; Principles and design of disaster resistant structures.

### Section 4: Environmental Planning and Design

Ecosystem- natural and man-made ecosystem; Ecological principles; Concepts of Environmental Impact Analysis; Environmental considerations in planning and design; Thermal comfort, ventilation and air movement; Principles of lighting and illumination; Climate responsive design; Solar architecture; Principles of architectural acoustics; Green Building- Concepts and Rating; ECBC; Building Performance Simulation and Evaluation; Environmental pollution- types, causes, controls and abatement strategies.

### Section 5: Urban Design

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

### Section 6: Urban Planning and Housing

Planning process; Types of plans - Master Plan, City Development Plan, Structure Plan, Zonal Plan, Action Area Plan, Town Planning Scheme, Regional Plan; Salient concepts, theories and principles of urban planning; Sustainable urban development; Emerging concepts of cities - Eco-City, Smart City, Transit Oriented Development (TOD), SEZ, SRZ etc.

Housing; Concepts, principles and examples of neighbourhood; Housing typologies; Slums; Affordable Housing; Housing for special areas and needs; Residential densities; Standards for housing and community facilities; National Housing Policies, Programs and Schemes.

### Section 7: Planning Techniques and Management

Tools and techniques of Surveys – Physical, Topographical, Land use and Socio- economic Surveys; Methods of non-spatial and spatial data analysis; Graphic presentation of spatial data; Application of G.I.S and Remote Sensing techniques in urban and regional planning; Decision support system and Land Information System.

Urban Economics; Law of demand and supply of land and its use in planning; Social, Economical and environmental cost benefit analysis; Techniques of financial appraisal; Management of Infrastructure Projects; Development guidelines such as URDPFI; Planning Legislation and implementation – Land Acquisition Act, PPP etc.; Local self-governance.

### Section 8: Services, Infrastructure and Transportation

**Building Services:** Water supply; Sewerage and drainage systems; Sanitary fittings and fixtures; Plumbing systems; Principles of internal and external drainage system; Principles of electrification of buildings; Intelligent Buildings; Elevators and Escalators - standards and uses; Air-Conditioning systems; Firefighting Systems; Building Safety and Security systems.

**Urban Infrastructure:** Transportation, Water Supply, Sewerage, Drainage, Solid Waste Management, Electricity and Communications.

**Process and Principles of Transportation Planning and Traffic Engineering:** Road capacity; Traffic survey methods; Traffic flow characteristics; Traffic analyses and design considerations; Travel demand forecasting; Land-use – transportation - urban form inter-relationships; Design of roads, intersections, grade separators and parking areas; Hierarchy of roads and level of service; Traffic and transport management and control in urban areas; Mass transportation planning; Para- transits and other modes of transportation, Pedestrian and slow moving traffic planning; Intelligent Transportation Systems.

**Principles of water supply and sanitation 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; Power Supply and Communication Systems, network, design and guidelines.

## **BM: Biomedical Engineering**

### **Section 1: Engineering Mathematics**

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

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

**Differential equations:** First order equation (linear and nonlinear), 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: 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 and standard deviation, random variables, discrete and continuous distributions: normal, Poisson and binomial distributions. Tests of Significance, statistical power analysis, and sample size estimation. Regression and correlation analysis.

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

### **Section 2: Electrical Circuits:**

Voltage and current sources: independent, dependent, ideal and practical; v-i relationships of resistor, inductor, mutual inductor 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 Capacitors.

### **Section 3: Signals and Systems**

Continuous and Discrete Signal and Systems: Periodic, aperiodic and impulse signals; Sampling theorem; 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; basics of IIR and FIR filters.

### **Section 4: Analog and Digital Electronics**

Characteristics and applications of diode, Zener diode, BJT and MOSFET; small signal analysis of transistor circuits, feedback amplifiers. Characteristics of operational amplifiers; applications of opamps: difference amplifier, adder, subtractor, integrator, differentiator, instrumentation amplifier, buffer.

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. Characteristics of ADC and DAC (resolution, quantization, significant bits, conversion/settling time); basics of number systems, microprocessor and microcontroller: applications, memory and input- output interfacing; elements of data acquisition systems.

## Section 5: 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 engineering – modeling system: transfer function and state-space model, stability analysis: time domain and frequency domain analysis.

## Section 6: Sensors and Bioinstrumentation

Types of Instruments: Resistive-, capacitive-, inductive-, piezoelectric-, Hall Effect sensors and associated signal conditioning circuits; Optical sources and detectors: LED, Photo-diode, p-i-n avalanche photodiode (APD), light dependent resistor and their characteristics; basics of magnetic sensing; Interferometer: applications in metrology; basics of fiber optic sensing. Basics of LASERS.

Origin, nature, and types of Biosignals, Principles of sensing physiological parameters, types of transducers and their characteristics, Electrodes for bioelectric signals, Bioelectric signals and their characteristics. Biopotential Amplifiers, Noise and artifacts and their management, Electrical Isolation (optical and electrical) and Safety of Biomedical Instruments. Generation, Acquisition, and signal conditioning and analysis of biosignals: ECG, EMG, EEG, EOG, Blood ERG, PCG, GSR. Principles of measuring blood pressure, Core temperature, volume & flow in arteries, veins and tissues – Lung volumes, respiration and cardiac output.

## Section 7: Human Anatomy and Physiology

Basic elements of human body-musculoskeletal system, respiratory system, circulatory system, excretory system, endocrine system, nervous system, digestive, nervous, immune, integumentary, and reproductive systems, Basics of cell and molecular biology.

## Section 8: Biomechanics

**Engineering Mechanics:** Free-body diagrams and equilibrium; trusses and frames; virtual work; kinematics and dynamics of particles and of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations, collisions.

**Hard Tissues:** Definition of Stress and Strain; Deformation Mechanics. Bone structure & composition mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, Maxwell & Voigt models – anisotropy, Fatigue Analysis,

**Soft Tissues:** Structure, functions, material properties and modeling of Soft Tissues: Cartilage, Tendon, Ligament, Muscle - Hodgkin-Huxley Model.

**Human Joints and Movements:** Skeletal joints, forces and stresses in human joints, types of joint, biomechanical analysis joints, parameterization and analysis in Gait,

**Biofluid mechanics:** Flow properties of blood, Dynamics of fluid flow in the intact human cardiovascular system - modeling and experimental approaches, Pulse wave velocities in arteries, Measurement/Estimation of In-vivo elasticity of blood vessels,

## Section 9: Medical Imaging Systems

Basic physics and Instrumentation of medical images in X-Ray, Ultrasound, CT, MRI, PET, FMRI, SPECT, and their characteristics.

## Section 10: Biomaterials

Basic properties of biomaterials, biocompatibility, bioactivity, biodegradable materials, Fundamentals of implants and medical devices, drug delivery carriers, scaffolds for tissue engineering.

# **BT: Biotechnology**

## 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.

**Differential Equations:** Linear and nonlinear first order ODEs, higher order ODEs with constant coefficients, Cauchy's and Euler's equations, Laplace transforms, PDE-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:** Solution of linear and nonlinear algebraic equations, Integration of trapezoidal and Simpson's rule, Single and multistep methods for differential equations.

## Section 2: General Biotechnology

**Biochemistry:** Biomolecules-structure and functions; Biological membranes, structure, action potential and transport processes; Enzymes- classification, kinetics and mechanism of action; Basic concepts and designs of metabolism (carbohydrates, lipids, amino acids and nucleic acids) photosynthesis, respiration and electron transport chain; Bioenergetics

**Microbiology:** Viruses- structure and classification; Microbial classification and diversity(bacterial, algal and fungal); Methods in microbiology; Microbial growth and nutrition; Aerobic and anaerobic respiration; Nitrogen fixation; Microbial diseases and host-pathogen interaction

**Cell Biology:** Prokaryotic and eukaryotic cell structure; Cell cycle and cell growth control; Cell-Cell communication, Cell signaling and signal transduction

**Molecular Biology and Genetics:** Molecular structure of genes and chromosomes; Mutations and mutagenesis; Nucleic acid replication, transcription, translation and their regulatory mechanisms in prokaryotes and eukaryotes; Mendelian inheritance; Gene interaction; Complementation; Linkage, recombination and chromosome mapping; Extra chromosomal inheritance; Microbial genetics (plasmids, transformation, transduction, conjugation); Horizontal gene transfer and Transposable elements; RNA interference; DNA damage and repair; Chromosomal variation; Molecular basis of genetic diseases

**Analytical Techniques:** Principles of microscopy-light, electron, fluorescent and confocal; Centrifugation-high speed and ultra; Principles of spectroscopy-UV, visible, CD, IR, FTIR, Raman, MS,NMR; Principles of chromatography- ion exchange, gel filtration, hydrophobic interaction, affinity, GC,HPLC, FPLC; Electrophoresis; Microarray

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

**Bioinformatics:** Major bioinformatics resources and search tools; Sequence and structure databases; Sequence analysis (biomolecular sequence file formats, scoring matrices, sequence alignment, phylogeny);Data mining and analytical tools for genomic and proteomic studies; Molecular dynamics and simulations (basic concepts including force fields, protein-protein, protein-nucleic acid, protein-ligand interaction)

## Section 3: Recombinant DNA Technology

Restriction and modification enzymes; Vectors; plasmid, bacteriophage and other viral vectors, cosmids, Ti plasmid, yeast artificial chromosome; mammalian and plant expression vectors; cDNA and genomic DNA library; Gene isolation, cloning and expression ; Transposons and gene targeting; DNA labeling; DNA sequencing; Polymerase chain reactions; DNA fingerprinting; Southern and northern blotting; In-situ hybridization; RAPD, RFLP; Site-directed mutagenesis; Gene transfer technologies; Gene therapy

## Section 4: Plant and Animal Biotechnology

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 by plant suspension cultures; Hairy root culture; transgenic plants; Plant products of industrial importance

Animal cell 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

### Section 5: Bioprocess Engineering and Process Biotechnology

Chemical engineering principles applied to biological system, Principle of reactor design, ideal and non-ideal multiphase bioreactors, mass and heat transfer; Rheology of fermentation fluids, Aeration and agitation; Media formulation and optimization; Kinetics of microbial growth, substrate utilization and product formation; Sterilization of air and media; Batch, fed-batch and continuous processes; Various types of microbial and enzyme reactors; Instrumentation control and optimization; Unit operations in solid-liquid separation and liquid-liquid extraction; Process scale-up, economics and feasibility analysis

Engineering principle of bioprocessing- Upstream production and downstream; Bioprocess design and development from lab to industrial scale; Microbial, animal and plant cell culture platforms; Production of biomass and primary/secondary metabolites; Biofuels, Bioplastics, industrial enzymes, antibiotics; Large scale production and purification of recombinant proteins; Industrial application of chromatographic and membrane based bioseparation methods; Immobilization of biocatalysts (enzymes and cells) for bioconversion processes; Bioremediation-Aerobic and anaerobic processes for stabilization of solid / liquid wastes

## 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 and Maclaurin 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, Stokes, Gauss and Green's theorems.

**Ordinary Differential Equation (ODE):** First order (linear and non-linear) equations; higher order linear equations with constant coefficients; Euler-Cauchy equations; Laplace transform and its application in solving linear ODEs; 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:** Definitions of probability and sampling theorems; Conditional probability; Discrete Random variables: Poisson and Binomial distributions; Continuous random variables: normal and exponential distributions; Descriptive statistics - Mean, median, mode and standard deviation; Hypothesis testing.

**Numerical Methods:** Accuracy and precision; error analysis. Numerical solutions of linear and non-linear algebraic equations; Least square approximation, 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; Kinematics of point mass and rigid body; Centre of mass; Euler's equations of motion; Impulse-momentum; Energy methods; Principles of virtual work.

**Solid Mechanics:** Bending moment and shear force in statically determinate beams; Simple stress and strain relationships; Theories of failures; Simple bending theory, flexural and shear stresses, shear centre; Uniform torsion, 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; Bricks and mortar; Timber; Bitumen. Construction Management: Types of construction projects; Tendering and construction contracts; Rate analysis and standard specifications; Cost estimation; Project planning and network analysis - PERT and CPM.

**Concrete Structures:** Working stress, Limit state and Ultimate load design concepts; Design of beams, slabs, columns; Bond and development length; Prestressed concrete; Analysis of beam sections at transfer and service loads.

**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; Plastic analysis of beams and frames.

### Section 3: Geotechnical Engineering

**Soil Mechanics:** Origin of soils, soil structure and fabric; Three-phase system and phase relationships, index properties; Unified and Indian standard soil classification system; Permeability - one dimensional flow, Darcy's law; Seepage through soils - two-dimensional flow, flow nets, uplift pressure, piping; Principle of effective stress, capillarity, seepage force and quicksand condition; Compaction in laboratory and field conditions; One- dimensional consolidation, time rate of consolidation; Mohr's circle, stress paths, effective and total shear strength parameters, characteristics of clays and sand.

**Foundation Engineering:** Sub-surface investigations - scope, 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, method of slices and Bishop's method; Stress distribution in soils - Boussinesq's and Westergaard's theories, 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 - types of piles, dynamic and static formulae, load capacity of piles in sands and clays, pile load test, negative skin friction.

### Section 4: Water Resources Engineering

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

**Hydraulics:** Forces on immersed bodies; Flow measurement in channels and pipes; Dimensional analysis and hydraulic similitude; Kinematics of flow, velocity triangles; Basics of hydraulic machines, specific speed of pumps and turbines; Channel Hydraulics - Energy-depth relationships, specific energy, critical flow, slope profile, hydraulic jump, uniform flow and gradually varied flow

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

**Irrigation:** Duty, delta, estimation of evapo-transpiration; Crop water requirements; Design of lined and unlined canals, head works, gravity dams and spillways; Design of weirs on permeable foundation; Types of irrigation systems, irrigation methods; Water logging and drainage; Canal regulatory works, cross-drainage structures, outlets and escapes.

## Section 5: Environmental Engineering

**Water and Waste Water:** Quality standards, basic unit processes and operations for water treatment. Drinking water standards, water requirements, basic unit operations and unit processes for surface water treatment, distribution of water. Sewage and sewerage treatment, quantity and characteristics of wastewater. Primary, secondary and tertiary treatment of wastewater, effluent discharge standards. Domestic wastewater treatment, quantity of characteristics of domestic wastewater, primary and secondary treatment. Unit operations and unit processes of domestic wastewater, sludge disposal.

**Air Pollution:** Types of pollutants, their sources and impacts, air pollution meteorology, air pollution control, air quality standards 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).

**Noise Pollution:** Impacts of noise, permissible limits of noise pollution, measurement of noise and control of noise pollution.

## Section 6: Transportation Engineering

**Transportation Infrastructure:** Highway alignment and engineering surveys; Geometric design of highways - cross-sectional elements, sight distances, horizontal and vertical alignments; Geometric design of railway track; Airport runway length, taxiway and exit taxiway design.

**Highway Pavements:** Highway materials - desirable properties and quality control tests; Design of bituminous paving mixes; Design factors for flexible and rigid pavements; Design of flexible pavement using IRC: 37-2012; Design of rigid pavements using IRC: 58-2011; Distresses in concrete pavements.

**Traffic Engineering:** Traffic studies on flow, speed, travel time - delay and O-D study, PCU, peak hour factor, parking study, accident study and analysis, statistical analysis of traffic data; Microscopic and macroscopic parameters of traffic flow, fundamental relationships; Control devices, signal design by Webster's method; Types of intersections and channelization; Highway capacity and level of service of rural highways and urban roads.

## 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 - scale, flying height; Remote sensing - basics, platform and sensors, visual image interpretation; Basics of Geographical information system (GIS) and Geographical Positioning system (GPS).

## 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, Newtonian and non-Newtonian fluids, shell-balances including differential form of Bernoulli equation and energy balance, Macroscopic friction factors, dimensional analysis and similitude, flow through pipeline systems, 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

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.

## Section 6: Chemical Reaction Engineering

Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, non-ideal reactors; residence time distribution, single parameter model; non-isothermal reactors; kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis.

## Section 7: Instrumentation and Process Control

Measurement of process variables; sensors, transducers and their dynamics, 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; 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 compressors, heat exchangers, multistage contactors.

## Section 9: Chemical Technology

Inorganic chemical industries (sulfuric acid, phosphoric acid, chlor-alkali industry), fertilizers (Ammonia, Urea, SSP and TSP); natural products industries (Pulp and Paper, Sugar, Oil, and Fats); petroleum refining



and petrochemicals; polymerization industries (polyethylene, polypropylene, PVC and polyester synthetic fibers).

## **CS: Computer Science and Information Technology**

### Section 1: Engineering Mathematics

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

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

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

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

## **Section 2 – 10: Computer Science and Information Technology**

### Section 2: Digital Logic

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

### Section 3: Computer Organization and Architecture

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

### Section 4: Programming and Data Structures

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

### Section 5: Algorithms

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

### Section 6: Theory of Computation

Regular expressions and finite automata. Context-free grammars and push-down 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.

### Section 8: Operating System

Processes, threads, inter-process communication, concurrency and synchronization. Deadlock. CPU scheduling. Memory management and virtual memory. File systems.

### Section 9: Databases

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

### Section 10: Computer Networks

Concept of layering. LAN technologies (Ethernet). Flow and error control techniques, switching. IPv4/IPv6, routers and routing algorithms (distance vector, link state). TCP/UDP and sockets, congestion control. Application layer protocols (DNS, SMTP, POP, FTP, HTTP). Basics of Wi-Fi. Network security:

authentication, basics of public key and private key cryptography, digital signatures and certificates, firewalls.

## **CY: Chemistry**

### Section 1: Physical Chemistry

**Structure:** Postulates of quantum mechanics. Time dependent and time independent Schrödinger equations. Born interpretation. Particle in a box. Harmonic oscillator. Rigid rotor. Hydrogen atom: atomic orbitals. Multi-electron atoms: orbital approximation. Variation and first order perturbation techniques. Chemical bonding: Valence bond theory and LCAO-MO theory. Hybrid orbitals. Applications of LCAO-MO to  $H_2^+$ ,  $H_2$  and other homonuclear diatomic molecules, heteronuclear diatomic molecules like HF, CO, NO, and to simple delocalized  $\pi$ -electron systems. Hückel approximation and its application to annular  $\pi$ -electron systems. Symmetry elements and operations. Point groups and character tables. Origin of selection rules for rotational, vibrational, electronic and Raman spectroscopy of diatomic and polyatomic molecules. Einstein coefficients. Relationship of transition moment integral with molar extinction coefficient and oscillator strength. Basic principles of nuclear magnetic resonance: nuclear g factor, chemical shift, nuclear coupling.

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

**Kinetics:** Transition state theory: Eyring equation, thermodynamic aspects. Potential energy surfaces and classical trajectories. Elementary, parallel, opposing and consecutive reactions. Steady state approximation. Mechanisms of complex reactions. Unimolecular reactions. Kinetics of polymerization and enzyme catalysis. Fast reaction kinetics: relaxation and flow methods. Kinetics of photochemical and photophysical processes.

**Surfaces and Interfaces:** Physisorption and chemisorption. Langmuir, Freundlich and 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. Chemistry of noble gases, pseudohalogenes, and interhalogen compounds. Acid-base concepts.

**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 diagrams, charge-transfer spectra. Magnetic properties of transition metal complexes. Reaction mechanisms: kinetic and thermodynamic stability, substitution and redox reactions.

**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:** Decay processes, half-life of radioactive elements, fission and fusion processes.

**Bioinorganic Chemistry:** Ion ( $\text{Na}^+$  and  $\text{K}^+$ ) 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<sub>2</sub>, ABX<sub>3</sub> type compounds, spinels, band theory, metals and semiconductors.

**Instrumental Methods of Analysis:** UV-visible spectrophotometry, NMR and ESR spectroscopy, mass spectrometry. Chromatography including GC and HPLC. Electroanalytical methods- polarography, cyclic voltammetry, ion-selective electrodes. Thermoanalytical methods.

### Section 3: Organic Chemistry

**Stereochemistry:** Chirality 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. Configurational and conformational effects, 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 identification of products, intermediates and isotopic labeling. Nucleophilic and electrophilic substitution reactions (both aromatic and aliphatic). Addition reactions to carbon-carbon and carbon-heteroatom (N,O) multiple bonds. Elimination reactions. Reactive intermediates – carbocations, carbanions, carbenes, nitrenes, arynes and free radicals. Molecular rearrangements involving electron deficient atoms.

**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 and Si based reagents in organic synthesis. Carbon-carbon bond formation through coupling reactions - Heck, Suzuki, Stille and Sonogoshira. Concepts of multistep synthesis - retrosynthetic analysis, strategic disconnections, synthons and synthetic equivalents. 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. Carbon-carbon bond forming reactions through enolates (including boron enolates), enamines and silyl enol ethers. Michael addition reaction. Stereoselective addition to C=O groups (Cram and Felkin-Anh models).

**Pericyclic Reactions and Photochemistry:** Electrocyclic, cycloaddition and sigmatropic reactions. Orbital correlations - FMO and PMO treatments. Photochemistry of alkenes, arenes and carbonyl compounds. Photooxidation and photoreduction. Di- $\pi$ -methane rearrangement, Barton reaction.

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

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

**Spectroscopy:** Applications of UV-visible, IR, NMR and Mass spectrometry in the structural determination of organic molecules.

## **EC:            Electronics and Communications**

### Section 1: Engineering Mathematics

**Linear Algebra:** Vector space, basis, linear dependence and independence, matrix algebra, eigenvalues and 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; Taylor's and Laurent's series, residue theorem.

**Numerical Methods:** Solution of nonlinear equations, single and multi-step methods for differential equations, convergence criteria.

**Probability and Statistics:** Mean, median, mode and standard deviation; combinatorial probability, probability distribution functions - binomial, Poisson, exponential and normal; Joint and conditional probability; Correlation and regression analysis.

### Section 2: Networks, Signals and Systems

**Network solution methods:** nodal and mesh analysis; Network theorems: superposition, Thevenin and Norton's, maximum power transfer; Wye-Delta transformation; Steady state sinusoidal analysis using phasors; Time domain analysis of simple linear circuits; Solution of network equations using Laplace transform; Frequency domain analysis of RLC circuits; Linear 2-port network parameters: driving point and transfer functions; State equations for networks.

**Continuous-time signals:** Fourier series and Fourier transform representations, sampling theorem and applications; Discrete-time signals: discrete-time Fourier transform (DTFT), DFT, FFT, Z-transform, interpolation of discrete-time signals; LTI systems: definition and properties, causality, stability, impulse response, convolution, poles and zeros, parallel and cascade structure, frequency response, group delay, phase delay, digital filter design techniques.

### Section 3: Electronic Devices

Energy bands in intrinsic and extrinsic silicon; Carrier transport: diffusion current, drift current, mobility and resistivity; Generation and recombination of carriers; Poisson and continuity equations; P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photo diode and solar cell; Integrated circuit fabrication process: oxidation, diffusion, ion implantation, photolithography and twin-tub CMOS process.

### Section 4: Analog Circuits

Small signal equivalent circuits of diodes, BJTs and MOSFETs; Simple diode circuits: clipping, clamping and rectifiers; Single-stage BJT and MOSFET amplifiers: biasing, bias stability, mid-frequency small signal analysis and frequency response; BJT and MOSFET amplifiers: multi-stage, differential, feedback, power and operational; Simple op-amp circuits; Active filters; Sinusoidal oscillators: criterion for oscillation, single-transistor and op- amp configurations; Function generators, wave-shaping circuits and 555 timers; Voltage reference circuits; Power supplies: ripple removal and regulation.

### Section 5: Digital Circuits

Number systems; Combinatorial circuits: Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates and their static CMOS implementations, arithmetic circuits, code converters, multiplexers, decoders and PLAs; Sequential circuits: latches and flip-flops, counters, shift-

registers and finite state machines; Data converters: sample and hold circuits, ADCs and DACs; Semiconductor memories: ROM, SRAM, DRAM; 8-bit microprocessor (8085): architecture, programming, memory and I/O interfacing.

### Section 6: Control Systems

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

### Section 7: Communications

**Random processes:** autocorrelation and power spectral density, properties of white noise, filtering of random signals through LTI systems; Analog communications: amplitude modulation and demodulation, angle modulation and demodulation, spectra of AM and FM, superheterodyne receivers, circuits for analog communications; Information theory: entropy, mutual information and channel capacity theorem; Digital communications: PCM, DPCM, digital modulation schemes, amplitude, phase and frequency shift keying (ASK, PSK, FSK), QAM, MAP and ML decoding, matched filter receiver, calculation of bandwidth, SNR and BER for digital modulation; Fundamentals of error correction, Hamming codes; Timing and frequency synchronization, inter-symbol interference and its mitigation; Basics of TDMA, FDMA and CDMA.

### Section 8: Electromagnetics

Electrostatics; 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; Waveguides: modes, boundary conditions, cut-off frequencies, dispersion relations; Antennas: antenna types, radiation pattern, gain and directivity, return loss, antenna arrays; Basics of radar; Light propagation in optical fibers.

## **EE: Electrical Engineering**

### Section 1: Engineering Mathematics

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

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

**Numerical Methods:** Solutions of nonlinear algebraic equations, Single and Multi-step methods for differential equations.

**Transform Theory:** Fourier Transform, Laplace Transform, z-Transform.

## *Electrical Engineering*

### Section 2: Electric Circuits

Network graph, KCL, KVL, Node and Mesh analysis, Transient response of dc and ac networks, Sinusoidal steady-state analysis, Resonance, Passive filters, Ideal current and voltage sources, Thevenin's theorem, Norton's theorem, Superposition theorem, Maximum power transfer theorem, Two-port networks, Three phase circuits, 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 operations, Linear Time Invariant and Causal systems, Fourier series representation of continuous periodic signals, Sampling theorem, Applications of Fourier Transform, Laplace Transform and z-Transform.

### Section 5: Electrical Machines

**Single phase transformer:** equivalent circuit, phasor diagram, open circuit and short circuit tests, regulation and efficiency; **Three phase transformers:** connections, parallel operation; **Auto-transformer,** Electromechanical energy conversion principles, **DC machines:** separately excited, series and shunt, motoring and generating mode of operation and their characteristics, starting and speed control of dc motors; **Three phase induction motors:** 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, regulation and parallel operation of generators, starting of synchronous motor, characteristics; Types of losses and efficiency calculations of electric machines.

### Section 6: Power Systems

Power generation concepts, ac and dc transmission concepts, Models and performance of transmission lines and cables, 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 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, Routh-Hurwitz and Nyquist criteria, Bode plots, Root loci, Stability analysis, Lag, Lead and Lead-Lag compensators; P, PI and PID controllers; State space model, State transition matrix.

### 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

Characteristics of diodes, BJT, MOSFET; Simple diode circuits: clipping, clamping, rectifiers; Amplifiers: Biasing, Equivalent circuit and Frequency response; Oscillators and Feedback amplifiers; Operational amplifiers: Characteristics and applications; Simple active filters, VCOs and Timers, Combinational and Sequential logic circuits, Multiplexer, Demultiplexer, Schmitt trigger, Sample and hold circuits, A/D and D/A converters, 8085 Microprocessor: Architecture, Programming and Interfacing.

## Section 10: Power Electronics

**Characteristics of semiconductor power devices:** Diode, Thyristor, Triac, GTO, MOSFET, IGBT; DC to DC conversion: Buck, Boost and Buck-Boost converters; Single and three phase configuration of uncontrolled rectifiers, Line commutated thyristor based converters, Bidirectional ac to dc voltage source converters, Issues of line current harmonics, Power factor, Distortion factor of ac to dc converters, Single phase and three phase inverters, Sinusoidal pulse width modulation.

## EY: Ecology and Evolution

### Section 1: Ecology

Population ecology; metapopulation dynamics; growth rates; density independent growth; density dependent growth; niche concept;

**Species interactions:** Plant-animal interactions; mutualism, commensalism, competition and predation; trophic interactions; functional ecology; ecophysiology; behavioural ecology;

**Community ecology:** Community assembly, organization and evolution; biodiversity: species richness, evenness and diversity indices; endemism; species-area relationships;

Ecosystem structure, function and services; nutrient cycles; biomes; habitat ecology; primary and secondary productivity; invasive species; global and climate change; applied ecology.

### Section 2: Evolution

Origin, evolution and diversification of life; natural selection; levels of selection.

Types of selection (stabilizing, directional etc.); sexual selection; genetic drift; gene flow; adaptation; convergence; species concepts;

Life history strategies; adaptive radiation; biogeography and evolutionary ecology;

Origin of genetic variation; Mendelian genetics; polygenic traits, linkage and recombination; epistasis, gene-environment interaction; heritability; population genetics;

Molecular evolution; molecular clocks; systems of classification: cladistics and phenetics; molecular systematics; gene expression and evolution.

### 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; neuroethology; evolutionary ethology; chemical, acoustic and visual signaling

Mating systems; sexual dimorphism; mate choice; parenting behaviour Competition; aggression; foraging behaviour; predator–prey interactions; Sociobiology: kin selection, altruism, costs and benefits of group-living.

## GG: Geology and Geophysics

### Part A: Common Section

Earth and Planetary 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; 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 – mineralogy and classification of common igneous, sedimentary and metamorphic rocks. Geological time scale - geochronology and absolute time. Stratigraphic principles; major stratigraphic divisions of India. Geological and geographical distribution of mineral, coal and petroleum resources of India.

Introduction to remote sensing. Engineering properties of rocks and soils. Ground water geology.

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

### Part B (Section-1): Geology

Geomorphic processes and agents; development and evolution of landforms; slope and drainage; processes in deep oceanic and near-shore regions; quantitative and applied geomorphology.

Mechanism of rock deformation; primary and secondary structures; geometry and genesis of folds, faults, joints and unconformities; cleavage, schistosity and lineation; methods of projection; tectonites and their significance; shear zones; superposed folding; basement-cover relationship.

Crystallography - symmetry, forms and twinning; crystal chemistry; optical mineralogy, classification of minerals, diagnostic physical and optical properties of rock - forming minerals.

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 geochemical thermodynamics; isotope geochemistry; geochemistry of waters including solution equilibria and water-rock interaction.

Igneous rocks – classification, forms and textures; magmatic differentiation; binary and ternary phase diagrams; major and trace elements as monitors of partial melting and magma evolutionary processes. Sedimentary rocks – texture and structure; sedimentary processes and environments, sedimentary facies, provenance and basin analysis. Metamorphic rocks – structures and textures.

Physico-chemical conditions of metamorphism and concept of metamorphic facies, grade and baric types; metamorphism of pelitic, mafic and impure carbonate rocks; role of fluids in metamorphism; metamorphic P-T-t paths and their tectonic significance. Association of igneous, sedimentary and metamorphic rocks with tectonic setting. Igneous and metamorphic provinces and important sedimentary basins of India.

Morphology, classification and geological significance of important invertebrates, vertebrates, plant fossils and microfossils.

Principles of Stratigraphy and concepts of correlation – lithostratigraphy, biostratigraphy and chronostratigraphy. Indian stratigraphy – Precambrian and Phanerozoic. Overview of Himalayan Geology.

Ore-mineralogy and optical properties of ore minerals; ore forming processes vis-à-vis ore-rock association (magmatic, hydrothermal, sedimentary, supergene and metamorphogenic ores); fluid inclusions as an ore genetic tool. 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. Origin and distribution of mineral, fossil and nuclear fuel deposits in India.

Engineering properties of rocks and soils; rocks as construction materials; role of geology in the construction of engineering structures including dams, tunnels and excavation sites; natural hazards. Ground water geology – exploration, well hydraulics and water quality. Basic principles of remote sensing – energy sources and radiation principles, atmospheric absorption, interaction of energy with earth's surface, aerial-photo interpretation, multispectral remote sensing in visible, infrared, thermal IR and



microwave regions, digital processing of satellite images. GIS – basic concepts, raster and vector mode operations.

## Part B (Section-2): Geophysics

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; earthquakes-causes and measurements, magnitude and intensity, focal mechanisms, earthquake quantification, source characteristics, seismotectonics and seismic hazards; digital seismographs,

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 theory; Eikonal equation and Ray theory.

Absolute and relative gravity measurements; Gravimeters, Land, airborne, shipborne and bore-hole gravity surveys; various corrections for gravity data reduction – free air, Bouguer and isostatic anomalies; density estimates of rocks; regional and residual gravity separation; principle of equivalent stratum; data enhancement techniques, upward and downward continuation; derivative maps, wavelength filtering; preparation and analysis of gravity maps; gravity anomalies and their interpretation – anomalies due to geometrical and irregular shaped bodies, depth rules, calculation of mass.– Elements of Earth's magnetic field, units of measurement, magnetic susceptibility of rocks and measurements, magnetometers, Land, airborne and marine magnetic 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-geometrical shaped bodies, depth estimates, Image processing concepts in processing of magnetic anomaly maps; Interpretation of processed magnetic anomaly data. Applications of gravity and magnetic methods for mineral and oil exploration.

Conduction of electricity through rocks, electrical conductivities of metals, non- metals, rock forming minerals and different rocks, concepts of D.C. resistivity measurement, various electrode configurations for resistivity sounding and profiling, application of filter theory, Type-curves over multi-layered structures, Dar-Zarrouck parameters, reduction of layers, coefficient of anisotropy, interpretation of resistivity field data, equivalence and suppression, self-potential and its origin, field measurement, Induced polarization, time and frequency domain IP measurements; interpretation and applications of IP, ground-water exploration, mineral exploration, environmental and engineering applications.

Basic concept of EM induction in the earth, Skin-depth, elliptic polarization, in phase and quadrature components, Various EM methods, measurements in different source-receiver configurations,. Earth's natural electromagnetic field, tellurics, magneto-tellurics; geomagnetic depth sounding principles, electromagnetic profiling, Time domain EM method, EM scale modeling, processing of EM data and interpretation. Geological applications including groundwater, mineral and hydrocarbon exploration.

Seismic methods of prospecting; 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, recording instruments (DFS), digital formats, field layouts, seismic noises and noise profile analysis, optimum geophone grouping, noise cancellation by shot and geophone arrays, 2D and 3D seismic data acquisition, processing and interpretation; CDP stacking charts, binning, filtering, dip-moveout, 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. Reservoir geophysics.

Geophysical signal processing, sampling theorem, aliasing, Nyquist frequency, 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.

Principles and techniques of geophysical well-logging, SP, resistivity, induction, gamma ray, neutron, density, sonic, temperature, dip meter, caliper, nuclear magnetic, cement bond logging, micro-logs. Quantitative evaluation of formations from well logs; well hydraulics and application of geophysical

methods for groundwater study; application of bore hole geophysics in ground water, mineral and oil exploration.

Radioactive methods of prospecting and assaying of mineral (radioactive and non radioactive) deposits, half-life, decay constant, radioactive equilibrium, G M counter, scintillation detector, semiconductor devices, application of radiometric for exploration, assaying and radioactive waste disposal.

Basic concepts of forward and inverse problems, Ill-posedness of inverse problems, condition number, non-uniqueness and stability of solutions; L1, L2 and Lp norms, overdetermined, underdetermined and mixed determined inverse problems, quasi-linear and non-linear methods including Tikhonov's regularization method, Singular Value Decomposition, Backus-Gilbert method, simulated annealing, genetic algorithms and artificial neural network.

## **IN: Instrumentation Engineering**

### **Section 1: Engineering Mathematics**

**Linear Algebra:** Matrix algebra, systems of linear equations, 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), 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: 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 and standard deviation, 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.

### **Instrumentation Engineering**

#### **Section 2: Electrical Circuits:**

**Voltage and current sources:** independent, dependent, ideal and practical; v-i relationships of resistor, inductor, mutual inductor 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.

One-port and two-port networks, driving point impedance and admittance, open-, and short circuit parameters.

#### **Section 3: 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 4: 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, P-I, P-I-D, cascade, feedforward, and ratio controllers.

### Section 5: Analog Electronics

Characteristics and applications of diode, Zener diode, BJT and MOSFET; small signal analysis of transistor circuits, feedback amplifiers. Characteristics of operational amplifiers; applications of opamps: difference amplifier, adder, subtractor, integrator, differentiator, instrumentation amplifier, precision rectifier, active filters and other circuits. Oscillators, signal generators, voltage controlled oscillators and phase locked loop.

### Section 6: Digital Electronics

Combinational logic circuits, minimization of Boolean functions. IC families: TTL and CMOS. Arithmetic circuits, comparators, Schmitt trigger, multi-vibrators, sequential circuits, flip-flops, 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, 8-bit microprocessor and microcontroller: applications, memory and input-output interfacing; basics of data acquisition systems.

### Section 7: Measurements

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. 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 8: 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 (differential pressure, 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.

### Section 9: 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-, pulse shift keying for digital modulation; optical sources and detectors: LED, laser, photo-diode, light dependent resistor and their characteristics; interferometer: applications in metrology; basics of fiber optic sensing.

## **MA: Mathematics**

**Calculus:** Finite, countable and uncountable sets, Real number system as a complete ordered field, Archimedean property; Sequences and series, convergence; Limits, continuity, uniform continuity, differentiability, mean value theorems; Riemann integration, Improper integrals; Functions of two or three 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; 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, eigenvalues and eigenvectors, minimal polynomial, Cayley-Hamilton Theorem, diagonalization, Jordan canonical form, symmetric, skew-symmetric, Hermitian, skew-Hermitian, orthogonal and unitary matrices; Finite dimensional inner product spaces, Gram-Schmidt orthonormalization process, definite forms.

**Real Analysis:** Metric spaces, connectedness, compactness, completeness; Sequences and series of functions, uniform convergence; Weierstrass approximation theorem; Power series; Functions of several variables: Differentiation, contraction mapping principle, Inverse and Implicit function theorems; Lebesgue measure, measurable functions; Lebesgue integral, Fatou's lemma, monotone convergence theorem, dominated convergence theorem.

**Complex Analysis:** 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 theorem and Laurent's theorem; residue theorem and applications for evaluating real integrals; Rouché's theorem, Argument principle, Schwarz lemma; conformal mappings, bilinear 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.

**Algebra:** Groups, subgroups, normal subgroups, quotient groups, homomorphisms, automorphisms; cyclic groups, permutation groups, Sylow's theorems and their applications; Rings, ideals, prime and maximal ideals, quotient rings, unique factorization domains, Principle ideal domains, Euclidean domains, polynomial rings and irreducibility criteria; Fields, finite fields, field extensions.

**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, Riesz representation theorem.

**Numerical Analysis:** Numerical solutions of algebraic and transcendental equations: bisection, secant method, Newton-Raphson method, fixed point iteration; Interpolation: error of polynomial interpolation, Lagrange and Newton interpolations; Numerical differentiation; Numerical integration: Trapezoidal and Simpson's rules; Numerical solution of a system of linear equations: direct methods (Gauss elimination, LU decomposition), iterative methods (Jacobi and Gauss-Seidel); Numerical solution of initial value problems of ODEs: Euler's method, Runge-Kutta methods of order 2.

**Partial Differential Equations:** Linear and quasi-linear first order partial differential equations, method of characteristics; Second order linear equations in two variables and their classification; Cauchy, Dirichlet and Neumann problems; Solutions of Laplace and wave equations in two dimensional Cartesian coordinates, interior and exterior Dirichlet problems in polar coordinates; Separation of variables method for solving wave and diffusion equations in one space variable; Fourier series and Fourier transform and Laplace transform methods of solutions for the equations mentioned above.

**Topology:** Basic concepts of topology, bases, subbases, subspace topology, order topology, product topology, metric topology, connectedness, compactness, countability and separation axioms, Urysohn's Lemma.

**Linear Programming:** Linear programming problem and its formulation, convex sets and their properties, graphical method, basic feasible solution, simplex method, two phase methods; infeasible and unbounded LPP's, alternate optima; Dual problem and duality theorems; Balanced and unbalanced transportation problems, Vogel's approximation method for solving transportation problems; Hungarian method for solving assignment problems.

## **ME: Mechanical Engineering**

### **Section 1: Engineering Mathematics**

**Linear Algebra:** Matrix algebra, systems of linear equations, eigenvalues and eigenvectors.

**Calculus:** Functions of single variable, limit, continuity and differentiability, mean value theorems, indeterminate forms; evaluation of definite and improper integrals; double and triple integrals; partial

derivatives, total derivative, Taylor series (in one and two variables), maxima and minima, Fourier series; gradient, divergence and curl, vector identities, directional derivatives, line, surface and volume integrals, applications of Gauss, Stokes and Green's theorems.

**Differential equations:** First order equations (linear and nonlinear); higher order linear differential equations with constant coefficients; Euler-Cauchy equation; initial and boundary value problems; Laplace transforms; solutions of heat, wave and Laplace's equations.

**Complex variables:** Analytic functions; Cauchy-Riemann equations; Cauchy's integral theorem and integral formula; Taylor and Laurent series.

**Probability and Statistics:** Definitions of probability, sampling theorems, conditional probability; mean, median, mode and standard deviation; random variables, binomial, Poisson and normal distributions.

**Numerical Methods:** Numerical solutions of linear and non-linear algebraic equations; integration by trapezoidal and Simpson's rules; single and multi-step methods for differential equations.

## Section 2: Applied Mechanics and Design

**Engineering Mechanics:** Free-body diagrams and equilibrium; trusses and frames; virtual work; kinematics and dynamics of particles and of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations, collisions.

**Mechanics of Materials:** Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; thin cylinders; shear force and bending moment diagrams; bending and shear stresses; deflection of beams; torsion of circular shafts; Euler's theory of columns; energy methods; thermal stresses; strain gauges and rosettes; testing of materials with universal testing machine; testing of hardness and impact strength.

**Theory of Machines:** Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of linkages; cams; gears and gear trains; flywheels and governors; balancing of reciprocating and rotating masses; gyroscope.

**Vibrations:** Free and forced vibration of single degree of freedom systems, effect of damping; vibration isolation; resonance; critical speeds of shafts.

**Machine Design:** Design for static and dynamic loading; failure theories; fatigue strength and the S-N diagram; principles of the design of machine elements such as bolted, riveted and welded joints; shafts, gears, rolling and sliding contact bearings, brakes and clutches, springs.

## Section 3: Fluid Mechanics and Thermal Sciences

**Fluid Mechanics:** Fluid properties; fluid statics, manometry, buoyancy, 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.

**Heat-Transfer:** Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system, Heisler's charts; thermal boundary layer, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes, effect of turbulence; heat exchanger performance, LMTD and NTU methods; radiative heat transfer, Stefan-Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis.

**Thermodynamics:** Thermodynamic systems and processes; properties of pure substances, behavior of ideal and real gases; zeroth and first laws of thermodynamics, calculation of work and heat in various processes; second law of thermodynamics; thermodynamic property charts and tables, availability and irreversibility; thermodynamic relations.

**Applications:** *Power Engineering:* Air and gas compressors; vapour and gas power cycles, concepts of regeneration and reheat. *I.C. Engines:* Air-standard Otto, Diesel and dual cycles. *Refrigeration and air-conditioning:* Vapour and gas refrigeration and heat pump cycles; properties of moist air, psychrometric

chart, basic psychrometric processes. *Turbo machinery*: Impulse and reaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbines.

#### Section 4: Materials, Manufacturing and Industrial Engineering

**Engineering Materials**: Structure and properties of engineering materials, phase diagrams, heat treatment, stress-strain diagrams for engineering materials.

**Casting, Forming and Joining Processes**: Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding.

**Machining and Machine Tool Operations**: Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining; principles of non-traditional machining processes; principles of work holding, design of jigs and fixtures.

**Metrology and Inspection**: Limits, fits and tolerances; linear and angular measurements; comparators; gauge design; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly.

**Computer Integrated Manufacturing**: Basic concepts of CAD/CAM and their integration tools.

**Production Planning and Control**: Forecasting models, aggregate production planning, scheduling, materials requirement planning.

**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; 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.

**Probability and Statistics**: Measures of central tendency; Random variables; Poisson, normal and binomial distributions; Correlation and regression analysis.

**Numerical Methods**: Solutions of linear algebraic equations; Integration of trapezoidal and Simpson's rule; Single and multi-step methods for differential equations.

### Section 2: Mine Development and Surveying

**Mine Development**: Methods of access to deposits; Underground drivages; Drilling methods and machines; Explosives, blasting devices and practices.

**Mine Surveying**: Levels and leveling, theodolite, tacheometry, triangulation; Contouring; Errors and adjustments; Correlation; Underground surveying; Curves; Photogrammetry; Field astronomy; EDM and Total Station; Introductory GPS .

### Section 3: Geomechanics and Ground Control

**Engineering Mechanics**: Equivalent force systems; Equations of equilibrium; Two dimensional frames and trusses; Free body diagrams; Friction forces; Particle kinematics and dynamics; Beam analysis.

**Geomechanics:** Geo-technical properties of rocks; Rock mass classification; Instrumentation and stress measurement techniques; Theories of rock failure; Ground vibrations; Stress distribution around mine openings; Subsidence; Rock bursts and coal bumps; Slope stability.

**Ground Control:** Design of pillars; Roof supporting systems; Mine filling.

#### Section 4: Mining Methods and Machinery

**Mining Methods:** Surface mining: layout, development, loading, transportation and mechanization, continuous surface mining systems; Underground coal mining: bord and pillar systems, room and pillar mining, longwall mining, thick seam mining methods; highwall mining; 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: haulages, conveyors, face and development machinery, hoisting systems, pumps, crushers.

#### Section 5: Surface Environment, Mine Ventilation, and Underground Hazards

**Surface Environment:** Air, water and soil pollution : Standards of quality, causes and dispersion of contamination, and control; Noise; Land reclamation.

**Mine Ventilation:** Underground atmosphere; Heat load sources and thermal environment, air cooling; Mechanics of air flow, distribution, natural and mechanical ventilation; Mine fans and their usage; Auxiliary ventilation; Ventilation planning; Ventilation networks.

**Subsurface Hazards:** Mine Gases. Underground hazards from fires, explosions, dust and inundation; Rescue apparatus and practices; Safety in mines; Accident data analysis; Mine lighting; Mine legislation; Occupational safety.

#### Section 6: Mine Economics, Mine Planning, Systems Engineering

**Mine Economics:** Mineral resource classification; Discounted cash flow analysis; Mine valuation; Mine investment analysis; Mineral taxation.

**Mine Planning:** Sampling methods, practices and interpretation; Reserve estimation techniques: Basics of geostatistics and quality control; Optimization of facility location; Work-study.

**Systems Engineering:** Concepts of reliability; Reliability of simple systems; Maintainability and availability; Linear programming, transportation and assignment problems; Network analysis; Inventory models; Queueing theory; Basics of simulation.

## **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; Correlation and regression analysis.

**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: Thermodynamics and Rate Processes

Laws of thermodynamics, activity, equilibrium constant, applications to metallurgical systems, solutions, phase equilibria, Ellingham and phase stability diagrams, thermodynamics of surfaces, interfaces and defects, adsorption and segregation; basic kinetic laws, order of reactions, rate constants and rate limiting steps; principles of electro chemistry- single electrode potential, electrochemical cells and polarizations, aqueous corrosion and protection of metals, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, selective leaching, oxidation and high temperature corrosion – characterization and control; heat transfer – conduction, convection and heat transfer coefficient relations, radiation, mass transfer – diffusion and Fick's laws, mass transfer coefficients; momentum transfer – concepts of viscosity, shell balances, Bernoulli's equation, friction factors.

## Section 3: Extractive Metallurgy

Minerals of economic importance, comminution techniques, size classification, flotation, gravity and other methods of mineral processing; agglomeration, pyro-, hydro-, and electro-metallurgical processes; material and energy balances; principles and processes for the extraction of non-ferrous metals – aluminum, copper, zinc, lead, magnesium, nickel, titanium and other rare metals; iron and steel making – principles, role structure and properties of slags, metallurgical coke, blast furnace, direct reduction processes, primary and secondary steel making, ladle metallurgy operations including deoxidation, desulphurization, sulphide shape control, inert gas rinsing and vacuum reactors; secondary refining processes including AOD, VAD, VOD, VAR and ESR; ingot and continuous casting; stainless steel making, furnaces and refractories.

## Section 4: Physical Metallurgy

Crystal structure and bonding characteristics of metals, alloys, ceramics and polymers, structure of surfaces and interfaces, nano-crystalline and amorphous structures; solid solutions; solidification; phase transformation and binary phase diagrams; principles of heat treatment of steels, cast iron and aluminum alloys; surface treatments; recovery, recrystallization and grain growth; structure and properties of industrially important ferrous and non-ferrous alloys; elements of X-ray and electron diffraction; principles of optical, scanning and transmission electron microscopy; industrial ceramics, polymers and composites; introduction to electronic basis of thermal, optical, electrical and magnetic properties of materials; introduction to electronic and opto-electronic materials.

## Section 5: Mechanical Metallurgy

Elasticity, yield criteria and plasticity; defects in crystals; elements of dislocation theory – types of dislocations, slip and twinning, source and multiplication of dislocations, stress fields around dislocations, partial dislocations, dislocation interactions and reactions; strengthening mechanisms; tensile, fatigue and creep behaviour; superplasticity; fracture – Griffith theory, basic concepts of linear elastic and elastoplastic fracture mechanics, ductile to brittle transition, fracture toughness; failure analysis; mechanical testing – tension, compression, torsion, hardness, impact, creep, fatigue, fracture toughness and formability.

## Section 6: Manufacturing Processes

Metal casting – patterns and moulds including mould design involving feeding, gating and risering, melting, casting practices in sand casting, permanent mould casting, investment casting and shell moulding, casting defects and repair; 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 – soldering, brazing and welding, common welding processes of shielded metal arc welding, gas metal arc welding, gas tungsten arc welding and submerged arc welding; Welding metallurgy, problems associated with welding of steels and aluminum alloys, defects in welded joints; Powder metallurgy – production of powders, compaction and sintering; NDT using dye- penetrant, ultrasonic, radiography, eddy current, acoustic emission and magnetic particle methods.



## **PE: Petroleum Engineering**

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

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

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

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

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

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

**Petroleum Exploration:** Classification and description of some common rocks with special reference to clastic and nonclastic reservoir rocks. Origin, migration and accumulation of Petroleum. Petroleum exploration methods.

**Oil and Gas Well Drilling Technology:** Well planning. Drilling method. Drilling rigs Rig operating systems. Drilling fluids function and properties. Drilling fluid maintenance equipment. Oil & gas well cementing operations. Drill bit types and their applications. Drill string & Casing string function, operations, selection & design. Drilling problems, their control & remedies. Directional drilling tools. Directional survey. Application of horizontal, multilateral, extended reach, slim wells.

**Reservoir Engineering:** Petrophysical properties of reservoir rocks. Coring and core analysis. Reservoir fluid properties. Phase behavior of hydrocarbon system. Flow of fluids through porous media. Water and gas coning. Reservoir pressure measurements. Reservoir drives, drive mechanics and recovery factors. Reserve estimation & techniques.

**Petroleum Production Operations:** Well equipments. Well completion techniques. Well production problems and mitigation. Well servicing & Workover operations. Workover & completion fluids. Formation damage. Well stimulation techniques. Artificial lift techniques. Field processing of oil & gas. Storage and transportation of petroleum and petroleum products. Metering and measurements oil & gas. Production system analysis & optimization. Production testing. Multiphase flow in tubing and flow-lines. Nodal system analysis. Pressure vessels, storage tanks, shell and tube heat exchangers, pumps and compressors, LNG value chain.

**Offshore Drilling and Production Practices:** Offshore oil and gas operations & ocean environment. Offshore fixed platforms, Offshore mobile units, Station keeping methods like mooring & dynamic positioning system. Offshore drilling from fixed platform, jack-up, ships and semi submersibles. Use of conductors and risers. Offshore well completion. Deep water applications of subsea technology. Offshore production: Oil processing platforms, water injection platforms, storage, SPM and SBM transportation and utilities. Deep water drilling rig. Deep water production system. Emerging deep water technologies.

**Petroleum Formation Evaluation:** Evaluation of petrophysical of sub-surface formations: Principles applications, advantages and disadvantages of SP, resistivity, radioactive, acoustic logs and types of tools used. Evaluation of CBL/VDL, USIT, SFT, RFT. Production logging tools, principles, limitations and applications. Special type of logging tools. Casing inspection tools (principles, applications and limitations), Formations micro scanner (FMS), NMR logging principles. Standard log interpretation methods. Cross-plotting methods.

**Oil and Gas Well Testing:** Diffusivity equation, derivation & solutions. Radius of investigation. Principle of superposition. Horner's approximation. Drill Stem Testing. Pressure Transient Tests: Drawdown and

build up-test analysis. Wellbore effects. Multilayer reservoirs. Injection well testing. Multiple well testing. Interference testing, Pulse testing, well-test analysis by use of type curves. Gas well testing.

**Health Safety and Environment in Petroleum Industry:** Health hazards in Petroleum Industry: Toxicity, Physiological, Asphyxiation, respiratory and skin effect of petroleum hydrocarbons, sour gases. Safety System: Manual & automatic shutdown system, blow down systems. Gas detection system. Fire detection and suppression systems. Personal protection system & measures. HSE Policies. Disaster & crisis management in Petroleum Industry. Environment: Environment concepts, impact on eco-system, air, water and soil. The impact of drilling & production operations on environment, Environmental transport of petroleum wastes. Offshore environmental studies. Offshore oil spill and oil spill control. Waste treatment methods.

**Enhanced Oil Recovery Techniques:** Basic principles and mechanism of EOR, Screening of EOR process. Concept of pattern flooding, recovery efficiency, permeability heterogeneity. Macroscopic and microscopic displacement efficiency. EOR methods: Chemical flooding, Miscible flooding, Thermal recoveries (steam stimulation, hot water & steam flooding, in-situ combustion), Microbial EOR.

**Latest trends in Petroleum Engineering:** Coal bed methane, shale gas, oil shale, gas hydrate, and heavy oil.

## **PH:           PHYSICS**

### **Section 1: Mathematical Physics**

**Linear vector space:** basis, orthogonality and completeness; matrices; vector calculus; linear differential equations; elements of complex analysis: Cauchy- Riemann conditions, Cauchy's theorems, singularities, residue theorem and applications; Laplace transforms, Fourier analysis; elementary ideas about tensors: covariant and contravariant tensor, Levi-Civita and Christoffel symbols.

### **Section 2: Classical Mechanics**

D'Alembert's principle, cyclic coordinates, variational principle, Lagrange's equation of motion, central force and scattering problems, rigid body motion; small oscillations, Hamilton's formalisms; Poisson bracket; 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; dielectrics and conductors; Maxwell's equations; scalar and vector potentials; Coulomb and Lorentz gauges; Electromagnetic waves and their reflection, refraction, interference, diffraction and polarization; 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; one-, two- and three-dimensional potential problems; particle in a box, transmission through one dimensional potential barriers, harmonic oscillator, hydrogen atom; linear vectors and operators in Hilbert space; angular momentum and spin; addition of angular momenta; time independent perturbation theory; elementary scattering theory.

### **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; LS and jj coupling; hyperfine structure; Zeeman and Stark effects; electric dipole transitions and selection rules; rotational and vibrational spectra of diatomic

molecules; electronic transition in diatomic molecules, Franck-Condon principle; Raman effect; NMR, ESR, X-ray spectra; lasers: Einstein coefficients, population inversion, two and three level systems.

### Section 7: Solid State Physics & Electronics

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, dielectric and magnetic properties of solids; elements of superconductivity: Type-I and Type II superconductors, Meissner effect, London equation.

**Semiconductor devices:** diodes, Bipolar Junction Transistors, Field Effect Transistors; operational amplifiers: negative feedback circuits, active filters and oscillators; regulated power supplies; basic digital logic circuits, sequential circuits, flip-flops, counters, registers, A/D and D/A conversion.

### Section 8: Nuclear and Particle Physics

Nuclear radii and charge distributions, nuclear binding energy, Electric and magnetic moments; nuclear models, liquid drop model: semi-empirical mass formula, Fermi gas model of nucleus, 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.

## 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, Solutions of one dimensional heat and wave equations and Laplace equation.

**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, Random variables, Poisson, Normal and Binomial 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: General Engineering

**Engineering Materials:** Structure and properties correlation; engineering materials (metals, ceramics, polymers and composites) – properties and applications; stress- strain behavior of metals and alloys; iron-carbon phase diagram, heat treatment of metals and alloys, its influence on mechanical properties.

**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 stress, Euler's theory of columns.

**Theory of Machines and Design:** Analysis of planar mechanisms, cams and followers; governors and fly wheels; design of bolted, riveted and welded joints; interference/shrink fit joints; design of shafts, keys, spur gears, belt drives, brakes and clutches; pressure vessels.

**Thermal and Fluids Engineering:** Fluid mechanics – fluid statics, Bernoulli's equation, flow through pipes, equations of continuity and momentum, capillary action, contact angle and wetting; thermodynamics –

zeroth, first and second law of thermodynamics, thermodynamic system 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; patterns – types and materials; allowances; moulds and cores – materials, making, and testing; casting techniques of cast iron, steels and nonferrous metals and alloys; analysis of solidification and microstructure development; design of gating and riser; origin of defects.

**Metal Forming:** Stress-strain relations in elastic and plastic deformation; concept of flow stress; hot and cold working – forging, rolling, extrusion and wire drawing; sheet metal working processes – blanking, bending and deep drawing; ideal work and slab analysis; origin of metal working defects.

**Joining of materials:** Principles of fusion welding processes (manual metal arc, MIG, TIG, plasma arc, submerged arc welding processes) – different heat sources (flame, arc, resistive, laser, electron beam), and heat transfer and associated losses, flux application, feeding of filler rod; Principles of solid state welding processes (friction, explosive welding, ultrasonic welding processes); Principles of adhesive, brazing and soldering processes; Origins of welding defects.

**Powder processing:** Production of metal/ceramic powders, compaction and sintering of metals and ceramic powders.

**Polymers and Composites:** Plastic processing – injection, compression and blow molding, extrusion, calendaring and thermoforming; molding of composites.

### Section 4: Manufacturing Processes II

**Machine Tools and Machining:** Basic machine tools like centre lathe, milling machine, and drilling machine – construction and kinematics; machining processes - turning, taper turning, thread cutting, drilling, boring, milling, gear cutting, thread production, grinding; geometry of single point cutting tools, chip formation, cutting forces, specific cutting energy and power requirements, Merchant's analysis; basis of selection of machining parameters; tool materials, tool wear and tool life, economics of machining, thermal aspects of machining, cutting fluids, machinability; Jigs and fixtures – principles, applications, and design

**Non-traditional Manufacturing:** Principles, applications, effect of process parameters on MRR and product quality of non-traditional machining processes – USM, AJM, WJM, AWJM, EDM and Wire cut EDM, LBM, EBM, PAM, CHM, ECM.

**Computer Integrated Manufacturing:** Basic concepts of CAD – geometric modeling, CAM – CNC and robotics – configurations, drives and controls, Group Technology and its applications – CAPP, cellular manufacturing and FMS.

### Section 5: Quality and Reliability

**Metrology and Inspection:** Limits, fits, and tolerances, gauge design, interchangeability, selective assembly; linear, angular, and form measurements (straightness, squareness, flatness, roundness, and cylindricity) by mechanical and optical methods; inspection of screw threads and gears; surface finish measurement by contact and non-contact methods; tolerance analysis in manufacturing and assembly.

**Quality management:** Quality – concept and costs; quality assurance; statistical quality control, acceptance sampling, zero defects, six sigma; total quality management; ISO 9000.

**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 maintenance and replacement.

### Section 6: Industrial Engineering

**Product Design and Development:** Principles of good product design, tolerance design; quality and cost considerations; product life cycle; standardization, simplification, diversification, value engineering and analysis, concurrent engineering; comparison of production alternatives.

**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, merit rating, incentive schemes, and wage administration.

**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; network flow models, constrained optimization and Lagrange multipliers; Markovian queuing models; dynamic programming; 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, time-cost trade-off, resource leveling.

**Production control:** Forecasting techniques – causal and time series models, moving average, exponential smoothing, trend and seasonality; aggregate production planning; master production scheduling; MRP and MRP-II; 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 – PERT and CPM.

## ST: Statistics

**Calculus:** Finite, countable and uncountable sets, Real number system as a complete ordered field, Archimedean property; Sequences and series, convergence; Limits, continuity, uniform continuity, differentiability, mean value theorems; Riemann integration, Improper integrals; Functions of two or three 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; 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; systems of linear equations, eigenvalues and eigenvectors, minimal polynomial, Cayley-Hamilton Theorem, diagonalization, Jordan canonical form, symmetric, skew-symmetric, Hermitian, skew- Hermitian, orthogonal and unitary matrices; Finite dimensional inner product spaces, Gram-Schmidt orthonormalization process, definite forms.

**Probability:** Classical, relative frequency and axiomatic definitions of probability, conditional probability, Bayes' theorem, independent events; Random variables and probability distributions, moments and moment generating functions, quantiles; Standard discrete and continuous univariate distributions; Probability inequalities (Chebyshev, Markov, Jensen); Function of a random variable; Jointly distributed random variables, marginal and conditional distributions, product moments, joint moment generating functions, independence of random variables; Transformations of random variables, sampling distributions, distribution of order statistics and range; Characteristic functions; Modes of convergence; Weak and strong laws of large numbers; Central limit theorem for i.i.d. random variables with existence of higher ordermoments.

**Stochastic Processes:** Markov chains with finite and countable state space, classification of states, limiting behaviour of n-step transition probabilities, stationary distribution, Poisson and birth-and-deathprocesses.

**Inference:** Unbiasedness, consistency, sufficiency, completeness, uniformly minimum variance unbiased estimation, method of moments and maximum likelihood estimations; Confidence intervals; Tests of hypotheses, most powerful and uniformly most powerful tests, likelihood ratio tests, large sample test,

Sign test, Wilcoxon signed rank test, Mann-Whitney U test, test for independence and Chi-square test for goodness of fit.

**Regression Analysis:** Simple and multiple linear regression, polynomial regression, estimation, confidence intervals and testing for regression coefficients; Partial and multiple correlation coefficients.

**Multivariate Analysis:** Basic properties of multivariate normal distribution; Multinomial distribution; Wishart distribution; Hotellings  $T^2$  and related tests; Principal component analysis; Discriminant analysis; Clustering.

**Design of Experiments:** One and two-way ANOVA, CRD, RBD, LSD,  $2^2$  and  $2^3$  Factorial experiments.

## **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; 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, 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; integration of trapezoidal and Simpson's rule; single and multi-step methods for differential equations.

### TEXTILE ENGINEERING AND FIBRE SCIENCE

#### Section 1: Textile Fibers

Classification of textile fibers; Essential requirements of fiber forming polymers; Gross and fine structure of natural fibers like cotton, wool, silk, Introduction to important bast fibres; properties and uses of natural and man-made fibres including carbon, aramid and ultra high molecular weight polyethylene (UHMWPE) fibres; physical and chemical methods of fiber and blend identification and blend analysis.

Molecular architecture, amorphous and crystalline phases, glass transition, plasticization, crystallization, melting, factors affecting  $T_g$  and  $T_m$ ; Production process of viscose and other regenerated cellulosic fibres such as polynosic, lyocell. Polymerization of nylon-6, nylon-66, poly (ethylene terephthalate), polyacrylonitrile and polypropylene; Melt Spinning processes for PET, polyamide and polypropylene; Wet and dry spinning processes for viscose and acrylic fibres; post spinning operations such as drawing, heat setting, tow-to-tow conversion and different texturing methods.

Methods of investigating fibre structure e.g., Density, X-ray diffraction, birefringence, optical and electron microscopy, I.R. spectroscopy, thermal methods (DSC, DMA/TMA, TGA); structure and morphology of man-made fibres, mechanical properties of fibres, moisture sorption in fibres; fibre structure and property correlation.

#### Section 2: Yarn manufacture, Yarn structure and Properties

Principles of opening, cleaning and mixing/blending of fibrous materials, working principle of modern opening and cleaning equipment; the technology of carding, carding of cotton and synthetic fibres; Drafting operation, roller and apron drafting principle, causes of mass irregularity introduced by drafting; roller arrangements in drafting systems; principles of cotton combing, combing cycle, mechanism and function, combing efficiency, lap preparation; recent developments in comber; Roving production, mechanism of bobbin building, roving twist; Principle of ring spinning, forces acting on yarn and traveler,

ring & traveler designs, mechanism of cop formation, causes of end breakages; Working principle of ring doubler and two for one twister, single and folded yarn twist, properties of double yarns, production of core spun yarn; Principles of compact, rotor, air jet, air vortex, core, wrap, twist less and friction spinning.

Yarn contraction, yarn diameter, specific volume & packing coefficient; Twist factor, twist strength relationship in spun yarns; Fibre configuration and orientation in yarn; Cause of fibre migration and its estimation; Irregularity index; Structure property relationship of compact ring, rotor, air-jet and friction spun yarns.

### Section 3: Fabric manufacture, Structure and Properties

Principles of winding processes and machines, random, precision and step precision winding, package faults and their remedies; Yarn clearers and tensioners; Different systems of yarn splicing; Features of modern cone winding machines; Different types of warping creels; features of modern beam and sectional warping machines; Different sizing systems, sizing of spun and filament yarns, sizing machines; Principles of pirn winding processes and machines.

Primary and secondary motions of loom, cam design & kinematics of sley, effect of their settings and timings on fabric formation, fabric appearance and weaving performance; Dobby and jacquard shedding; Mechanics of weft insertion with shuttle, warp and weft stop motions, warp protection, weft replenishment; Principles of weft insertion systems of shuttle-less weaving machines; Principles of multiphase and circular looms.

Principles of weft and warp knitting, basic weft and warp knitted structures; Classification, production, properties and application of nonwoven fabrics, principle of web formation & bonding.

Basic woven fabric constructions and their derivatives; crepe, cord, terry, gauze, leno and double cloth constructions. Peirce's equations for fabric geometry; elastica model of plain woven fabrics; thickness, cover and maximum set of woven fabrics.

### Section 4: Textile Testing

Sampling techniques, sample size and sampling errors; Measurement of fibre length, fineness, crimp; measurement of cotton fiber maturity and trash content; High volume fibre testing; Measurement of yarn count, twist and hairiness; Tensile testing of fibers, yarns and fabrics; Evenness testing of slivers, rovings and yarns; Classimat fault analysis; Testing equipment for measurement of fabric properties like thickness, compressibility, air permeability, wetting & wicking, drape, crease recovery, tear strength, bursting strength and abrasion resistance; Instruments and systems for objective evaluation of fabric hand. Statistical analysis of experimental results, frequency distributions, correlation, significance tests, analysis of variance and control charts.

### Section 5: Chemical processing

Impurities in natural fibre; Chemistry and practice of preparatory processes for cotton, wool and silk; Mercerization of cotton; Preparatory processes for manmade fibres and their blends.

Classification of dyes; Dyeing of cotton, wool, silk, polyester, nylon and acrylic with appropriate dye classes; Dyeing of polyester/cotton and polyester/wool blends; Dyeing machines; Dyeing of cotton knitted fabrics and machines used; Dye fibre interaction; Introduction to thermodynamics and kinetics of dyeing; Methods for determination of wash, light and rubbing fastness.

Styles of printing; Printing thickeners including synthetic thickeners; Printing auxiliaries; Printing of cotton with reactive dyes, wool, silk, nylon with acid and metal complex dyes, Printing of polyester with disperse dyes; Pigment printing; Resist and discharge printing of cotton, silk and polyester; Transfer printing of polyester; Inkjet printing.

Mechanical finishing of cotton. Stiff, soft, wrinkle resistant, water repellent, flame retardant and enzyme (bio-polishing) finishing of cotton; Milling, decatizing and shrink resistant finishing of wool; Antistatic and soil release finishing; Heat setting of synthetic fabrics; Minimum application techniques; Pollution control and treatment of effluents.

## **XE-A: Engineering Mathematics (Compulsory for all XE candidates)**

### Section 1: Linear Algebra

Algebra of matrices; Inverse and rank of a matrix; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Determinants; Eigenvalues and eigenvectors; Diagonalisation of matrices; Cayley-Hamilton Theorem.

### Section 2: Calculus

**Functions of single variable:** Limit, continuity and differentiability; Mean value theorems; Indeterminate forms and L'Hospital's rule; Maxima and minima; Taylor's theorem; Fundamental theorem and mean value-theorems of integral calculus; Evaluation of definite and improper integrals; Applications of definite integrals to evaluate areas and volumes.

**Functions of two variables:** Limit, continuity and partial derivatives; Directional derivative; Total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Double and triple integrals, and their applications.

**Sequence and series:** Convergence of sequence and series; Tests for convergence; Power series; Taylor's series; Fourier Series; Half range sine and cosine series.

### Section 3: Vector Calculus

Gradient, divergence and curl; Line and surface integrals; Green's theorem, Stokes theorem and Gauss divergence theorem (without proofs).

### Section 3: Complex variables

Analytic functions; Cauchy-Riemann equations; Line integral, Cauchy's integral theorem and integral formula (without proof); Taylor's series and Laurent series; Residue theorem (without proof) and its applications.

### Section 4: Ordinary Differential Equations

First order equations (linear and nonlinear); Higher order linear differential equations with constant coefficients; Second order linear differential equations with variable coefficients; Method of variation of parameters; Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

### Section 5: Partial Differential Equations

Classification of second order linear partial differential equations; Method of separation of variables; Laplace equation; Solutions of one dimensional heat and wave equations.

### Section 6: Probability and Statistics

Axioms of probability; Conditional probability; Bayes' Theorem; Discrete and continuous random variables: Binomial, Poisson and normal distributions; Correlation and linear regression.

### Section 7: Numerical Methods

Solution of systems of linear equations using LU decomposition, Gauss elimination and Gauss-Seidel methods; Lagrange and Newton's interpolations, Solution of polynomial and transcendental equations by Newton-Raphson method; Numerical integration by trapezoidal rule, Simpson's rule and Gaussian quadrature rule; Numerical solutions of first order differential equations by Euler's method and 4th order Runge-Kutta method.

## **XE-B: Fluid Mechanics**

### Section 1: Flow and Fluid Properties

Viscosity, relationship between stress and strain-rate for Newtonian fluids, incompressible and compressible flows, differences between laminar and turbulent flows. Hydrostatics: Buoyancy, manometry, forces on submerged bodies.



## Section 2: Kinematics

Eulerian and Lagrangian description of fluids motion, concept of local and convective accelerations, steady and unsteady flows.

## Section 3: Integral analysis

Control volume analysis for mass, momentum and energy.

## Section 4: Differential Analysis

Differential equations of mass and momentum for incompressible flows: inviscid - Euler equation and viscous flows - Navier-Stokes equations, concept of fluid rotation, vorticity, stream function, Exact solutions of Navier-Stokes equation for Couette Flow and Poiseuille flow.

## Section 5: Inviscid flows

Bernoulli's equation - assumptions and applications, potential function, Elementary plane flows - uniform flow, source, sink and doublet and their superposition for potential flow past simple geometries.

## Section 6: Dimensional analysis

Concept of geometric, kinematic and dynamic similarity, some common non-dimensional parameters and their physical significance: Reynolds number, Froude number and Mach number.

## Section 7: Internal flows

Fully developed pipe flow, empirical relations for laminar and turbulent flows: friction factor and Darcy-Weisbach relation.

## Section 8: Prandtl boundary layer equations

Concept and assumptions, qualitative idea of boundary layer and separation, streamlined and bluff bodies, drag and lift forces. Flow measurements: Basic ideas of flow measurement using venturimeter, pitot-static tube and orifice plate.

## **XE-C: Materials Science**

### Section 1: Processing of Materials:

Powder synthesis, sintering, chemical methods, crystal growth techniques, zone refining, preparation of nanoparticles and thin films

### Section 2: Characterisation Techniques:

X-ray diffraction, spectroscopic techniques like UV-vis, IR, Raman. Optical and Electron microscopy

### Section 3: Structure and Imperfections:

Crystal symmetry, point groups, space groups, indices of planes, close packing in solids, bonding in materials, coordination and radius ratio concepts, point defects, dislocations, grain boundaries, surface energy and equilibrium shapes of crystals

### Section 4: Thermodynamics and Kinetics:

Phase rule, phase diagrams, solid solutions, invariant reactions, lever rule, basic heat treatment of metals, solidification and phase transformations, Fick's laws of diffusion, mechanisms of diffusion, temperature dependence of diffusivity

### Section 5: Properties of Materials:

**Mechanical Properties:** Stress-strain response of metallic, ceramic and polymer materials, yield strength, tensile strength and modulus of elasticity, toughness, plastic deformation, fatigue, creep and fracture

**Electronic Properties:** Free electron theory, Fermi energy, density of states, elements of band theory, semiconductors, Hall effect, dielectric behaviour, piezo, ferro, pyroelectric materials

**Magnetic Properties:** Origin of magnetism in metallic and ceramic materials, paramagnetism, diamagnetism, ferro and ferrimagnetism

**Thermal Properties:** Specific heat, thermal conductivity and thermal expansion, thermoelectricity

**Optical Properties:** Refractive index, absorption and transmission of electromagnetic radiation in solids, electrooptic and magneto-optic materials, spontaneous and stimulated emission, gas and solid state lasers

### Section 6: Material types

Concept of amorphous, single crystals and polycrystalline materials, crystallinity and its effect on physical properties, metal, ceramic, polymers, classification of polymers, polymerization, structure and properties, additives for polymer products, processing and applications, effect of environment on materials, composites

### Section 7: Environmental Degradation

Corrosion, oxidation and prevention

### Section 8: Elements of Quantum Mechanics and Mathematics

Basics of quantum mechanics, quantum mechanical treatment of electrical, optical and thermal properties of materials, analytical solid geometry, differentiation and integration, differential equations, vectors and tensors, matrices, Fourier series, complex analysis, probability and statistics

## **XE-D: Solid Mechanics**

Equivalent force systems; free-body diagrams; equilibrium equations; analysis of determinate trusses and frames; friction; particle kinematics and dynamics; dynamics of rigid bodies under planar motion; law of conservation of energy; law of conservation of momentum.

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, shear 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.

Free vibration of single degree of freedom systems.

## **XE-E: Thermodynamics**

### Section 1: Basic Concepts

Continuum and macroscopic approach; thermodynamic systems (closed and open); thermodynamic properties and equilibrium; state of a system, state postulate for simple compressible substances, state diagrams, paths and processes on state diagrams; concepts of heat and work, different modes of work; zeroth law of thermodynamics; concept of temperature.

### Section 2: First Law of Thermodynamics

Concept of energy and various forms of energy; internal energy, enthalpy; specific heats; first law applied to elementary processes, closed systems and control volumes, steady and unsteady flow analysis.

### Section 3: Second Law of Thermodynamics

Limitations of the first law of thermodynamics, concepts of heat engines and heat pumps/refrigerators, Kelvin-Planck and Clausius statements and their equivalence; reversible and irreversible processes; Carnot cycle and Carnot principles/theorems; thermodynamic temperature scale; Clausius inequality and concept of entropy; microscopic interpretation of entropy, the principle of increase of entropy, T-s diagrams; second law analysis of control volume; availability and irreversibility; third law of thermodynamics.

#### Section 4: Properties of Pure Substances

Thermodynamic properties of pure substances in solid, liquid and vapor phases; P-v- T behaviour of simple compressible substances, phase rule, thermodynamic property tables and charts, ideal and real gases, ideal gas equation of state and van der Waals equation of state; law of corresponding states, compressibility factor and generalized compressibility chart.

#### Section 5: Thermodynamic Relations

T-ds relations, Helmholtz and Gibbs functions, Gibbs relations, Maxwell relations, Joule-Thomson coefficient, coefficient of volume expansion, adiabatic and isothermal compressibilities, Clapeyron and Clapeyron-Clausius equations.

#### Section 6: Thermodynamic Cycles

Carnot vapor cycle, ideal Rankine cycle, Rankine reheat cycle, air-standard Otto cycle, air-standard Diesel cycle, air-standard Brayton cycle, vapor-compression refrigeration cycle.

#### Section 7: Ideal Gas Mixtures

Dalton's and Amagat's laws, properties of ideal gas mixtures, air-water vapor mixtures and simple thermodynamic processes involving them; specific and relative humidities, dew point and wet bulb temperature, adiabatic saturation temperature, psychrometric chart.

### **XE-F: Polymer Science and Engineering**

#### Section 1: Chemistry of high polymers

Monomers, functionality, degree of polymerizations, classification of polymers, glass transition, melting transition, criteria for rubberiness, polymerization methods: addition and condensation; their kinetics, metallocene polymers and other newer techniques of polymerization, copolymerization, monomer reactivity ratios and its significance, kinetics, different copolymers, random, alternating, azeotropic copolymerization, block and graft copolymers, techniques for copolymerization- bulk, solution, suspension, emulsion.

#### Section 2: Polymer Characterization

Solubility and swelling, 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.

#### Section 3: Synthesis 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: 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.

#### 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.

#### Section 5: Polymer Technology

Polymer compounding-need and significance, different compounding ingredients for rubber and plastics, cross-linking and vulcanization, vulcanization kinetics.

#### Section 6: Polymer rheology

Flow of Newtonian and non-Newtonian fluids, different flow equations, dependence of shear modulus on temperature, molecular/segmental deformations at different zones and transitions. Measurements of rheological parameters by capillary rotating, parallel plate, cone-plate rheometer. Visco- elasticity-creep

and stress relaxations, mechanical models, control of rheological characteristics through compounding, rubber curing in parallel plate viscometer, ODR and MDR.

### Section 7: Polymer processing

Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, pultrusion, calendaring, rotational molding, thermoforming, rubber processing in two-roll mill, internal mixer.

### 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.

## **XE - G: Food Technology**

### Section 1: Food Chemistry and Nutrition

**Carbohydrates:** structure and functional properties of mono-, oligo-, & poly- saccharides including starch, cellulose, pectic substances and dietary fibre, gelatinization and retrogradation of starch. **Proteins:** classification and structure of proteins in food, biochemical changes in post mortem and tenderization of muscles. **Lipids:** classification and structure of lipids, rancidity, polymerization and polymorphism. **Pigments:** carotenoids, chlorophylls, anthocyanins, tannins and myoglobin. **Food flavours:** terpenes, esters, aldehydes, ketones and quinines. **Enzymes:** specificity, simple and inhibition kinetics, coenzymes, enzymatic and non-enzymatic browning. **Nutrition:** balanced diet, essential amino acids and essential fatty acids, protein efficiency ratio, water soluble and fat soluble vitamins, role of minerals in nutrition, co-factors, anti-nutrients, nutraceuticals, nutrient deficiency diseases. Chemical and biochemical changes: changes occur in foods during different processing.

### Section 2: Food Microbiology

**Characteristics of microorganisms:** morphology of bacteria, yeast, mold and actinomycetes, spores and vegetative cells, gram-staining. **Microbial 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 pack aging and storage:** packaging materials, aseptic packaging, controlled and modified atmosphere storage. **Cereal processing and products:** milling of rice, wheat, and maize, parboiling of paddy, bread, biscuits, extruded products and ready to eat breakfast cereals. **Oil processing:** expelling, solvent extraction, refining and hydrogenation. **Fruits and vegetables processing:** extraction, clarification, concentration and packaging of fruit juice, jam, jelly, marmalade, squash, candies, tomato sauce, ketchup, and puree, potato chips, pickles. **Plantation crops processing and products:** tea, coffee, cocoa, spice, extraction of essential oils and oleoresins from spices. **Milk and milk products processing:** pasteurization and sterilization, cream, butter, ghee, ice-cream, cheese and milk powder. **Processing of animal products:** drying, canning, and freezing of fish and meat; production of egg powder. **Waste utilization:** pectin from fruit wastes, uses of by-products from rice milling. **Food standards and quality maintenance:** FPO, PFA, A-Mark, ISI, HACCP, food plant sanitation and cleaning in place (CIP).

### Section 4: Food Engineering

Mass and energy balance; Momentum transfer: Flow rate and pressure drop relationships for Newtonian fluids flowing through pipe, Reynolds number. Heat transfer: heat transfer by conduction, convection,

radiation, heat exchangers. Mass transfer: molecular diffusion and Flick's law, conduction and convective mass transfer, permeability through single and multilayer films. Mechanical operations: size reduction of solids, high pressure homogenization, filtration, centrifugation, settling, sieving, mixing & agitation of liquid. Thermal operations: thermal sterilization, evaporation of liquid foods, hot air drying of solids, spray and freeze-drying, freezing and crystallization. Mass transfer operations: psychrometric, humidification and dehumidification operations.

## **XE-H: Atmospheric & Ocean Science**

### **Section A: Atmospheric Science**

Fundamental of Meteorology, Thermal structure of the atmosphere and its composition, Radiation Balance and Laws, Wind Belts, Monsoon, Climate. Atmospheric Thermodynamics. Hydrostatic equilibrium and: Hydrostatic equation, variation of pressure with height, geopotential, Tropical convection. Atmospheric Electricity. Cloud Physics. Observation Techniques of the Atmosphere Properties.

Fundamental equations. Pressure, gravity, centripetal and Coriolis forces, continuity equation in Cartesian and isobaric coordinates, Scale analysis, inertial flow, geostrophic and gradient winds, thermal wind, vorticity. Atmospheric turbulence, baroclinic instability. Atmospheric Waves.

Tropical meteorology: Trade wind inversion, ITCZ; monsoon trough tropical cyclones, their structure and development theory; monsoon depressions; Climate variability and forcings; Madden-Julian oscillation (MJO), ENSO, QBO (quasi-biennial oscillation) and sunspot cycles. Primitive equations of Numerical Weather Prediction. General Circulation and Climate Modelling.

Synoptic weather forecasting, prediction of weather elements such as rain, maximum and minimum temperature and fog. Data Assimilation.

### **Section B: Ocean Sciences**

Seawater Properties, T-S diagrams, Ocean Observations, Ocean Tide and Waves and their properties. Coastal processes and Estuary Dynamics. coastal zone management. Wind Driven Circulation: Ekman, Sverdrup, Stommel and Munk theories, Inertial currents; geostrophic motion; barotropic and baroclinic conditions; Oceanic eddies. Global conveyor belt circulation. Subtropical gyres; Western boundary currents; equatorial current systems; Current System in the Indian Ocean.

Momentum equation, mass conservation, vorticity. Ocean and Wave Modeling, Ocean State Forecasting. Data Assimilation. Ocean Turbulence.

Chemical Property of seawater, major and minor elements, their behavior and chemical exchanges across interfaces and residence times in seawater, Element chemistry in atypical conditions-estuaries, Biochemical cycling of nutrients, trace metals and organic matter. Air-sea exchange of important biogenic dissolved gases; carbon dioxide-carbonate system; alkalinity and control of pH; biological pump. Marine Pollution. Primary and secondary production; factors controlling phytoplankton and zooplankton abundance and diversity; nekton and fisheries oceanography.

## **XL-P: Chemistry (Compulsory for all XL candidates)**

### **Section 1: Atomic Structure and Periodicity**

Planck's quantum theory, wave particle duality, uncertainty principle, quantum mechanical model of hydrogen atom, electronic configuration of atoms and ions. Periodic table and periodic properties: ionization energy, electron affinity, electronegativity and atomic size.

### **Section 2: Structure and Bonding**

Ionic and covalent bonding, MO and VB approaches for diatomic molecules, VSEPR theory and shape of molecules, hybridization, resonance, dipole moment, structure parameters such as bond length, bond angle and bond energy, hydrogen bonding and van der Waals interactions. Ionic solids, ionic radii and lattice energy (Born-Haber cycle). HSAB principle.

### Section 3: s, p and d Block Elements

Oxides, halides and hydrides of alkali, alkaline earth metals, B, Al, Si, N, P, and S. General characteristics of 3d elements. Coordination complexes: valence bond and crystal field theory, color, geometry, magnetic properties and isomerism.

### Section 4: Chemical Equilibria

Colligative properties of solutions, ionic equilibria in solution, solubility product, common ion effect, hydrolysis of salts, pH, buffer and their applications. Equilibrium constants ( $K_c$ ,  $K_p$  and  $K_x$ ) for homogeneous reactions.

### Section 5: Electrochemistry

Conductance, Kohlrausch law, cell potentials, emf, Nernst equation, Galvanic cells, 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.

### Section 7: Thermodynamics

First law, reversible and irreversible processes, internal energy, enthalpy, Kirchoff equation, heat of reaction, Hess's law, heat of formation. Second law, entropy, free energy and work function. Gibbs-Helmholtz equation, Clausius-Clapeyron equation, free energy change, equilibrium constant and Trouton's rule. Third law of thermodynamics.

### Section 8: Structure-Reactivity Correlations and Organic Reaction Mechanisms

Acids and bases, electronic and steric effects, optical and geometrical isomerism, tautomerism, conformers and concept of aromaticity. Elementary treatment of  $SN_1$ ,  $SN_2$ ,  $E_1$  and  $E_2$  reactions, Hoffmann and Saytzeff rules, addition reactions, Markownikoff rule and Kharash effect. Aromatic electrophilic substitutions, orientation effect as exemplified by various functional groups. Diels-Alder, Wittig and hydroboration reactions. Identification of functional groups by chemical tests.

## **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 and function: Myoglobin, Hemoglobin, Lysozyme, Ribonuclease A, Carboxypeptidase and Chymotrypsin.

### Section 2:

Enzyme kinetics including its regulation and inhibition, Vitamins and Coenzymes ; Metabolism and bioenergetics; 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, Characterization of biomolecules by electrophoresis, UV-visible and fluorescence spectroscopy and Mass spectrometry.

### Section 4:

Cell structure and organelles; Biological membranes; Transport across membranes; Signal transduction; Hormones and neurotransmitters.

## Section 5:

DNA replication, transcription and translation; Biochemical regulation of gene expression; Recombinant DNA technology and applications: PCR, site directed mutagenesis and DNA-microarray.

## Section 6:

**Immune system:** Active and passive immunity; Complement system; Antibody structure, function and diversity; Cells of the immune system: T, B and macrophages; T and B cell activation; Major histocompatibility complex; T cell receptor; Immunological techniques: Immunodiffusion, immunoelectrophoresis, RIA and ELISA.

# **XL-R: Botany**

## Section 1: Plant Systematics

Major systems of classification, plant groups, phylogenetic relationships and molecular systematics.

## Section 2: Plant Anatomy:

Plant cell structure and its components; cell wall and membranes; organization, organelles, cytoskeleton, anatomy of root, stem and leaves, floral parts, embryo and young seedlings, meristems, vascular system, their ontogeny, structure and functions, secondary growth in plants and stellar organization.

## Section 3: Morphogenesis & Development

Cell cycle, cell division, life cycle of an angiosperm, pollination, fertilization, embryogenesis, seed formation, seed storage proteins, seed dormancy and germination.

Concept of cellular totipotency, clonal propagation; organogenesis and somatic embryogenesis, artificial seed, somaclonal variation, secondary metabolism in plant cell culture, embryo culture, *in vitro* fertilization.

## Section 4: Physiology and Biochemistry

Plant water relations, transport of minerals and solutes, stress physiology, stomatal physiology, signal transduction, N<sub>2</sub> metabolism, photosynthesis, photorespiration; respiration, Flowering: photoperiodism and vernalization, biochemical mechanisms involved in flowering; molecular mechanism of senescence and aging, biosynthesis, mechanism of action and physiological effects of plant growth regulators, structure and function of biomolecules, (proteins, carbohydrates, lipids, nucleic acid), enzyme kinetics.

## Section 5: Genetics

Principles of Mendelian inheritance, linkage, recombination, genetic mapping; extrachromosomal inheritance; prokaryotic and eukaryotic genome organization, regulation of gene expression, gene mutation and repair, chromosomal aberrations (numerical and structural), transposons.

## Section 6: Plant Breeding and Genetic Modification

Principles, methods – selection, hybridization, heterosis; male sterility, genetic maps and molecular markers, sporophytic and gametophytic self incompatibility, haploidy, triploidy, somatic cell hybridization, marker-assisted selection, gene transfer methods viz. direct and vector-mediated, plastid transformation, transgenic plants and their application in agriculture, molecular pharming, plantibodies.

## Section 7: Economic 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.

## 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, mechanism(s) of pathogenesis and resistance, molecular detection of pathogens; plant-microbe beneficial interactions.

## Section 9: Ecology and Environment

Ecosystems – types, dynamics, degradation, ecological succession; food chains and energy flow; vegetation types of the world, pollution and global warming, speciation and extinction, conservation strategies, cryopreservation, phytoremediation.

## **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; Theory and practice of sterilization; Principles of microbial nutrition; Enrichment culture techniques for isolation of microorganisms; Light-, phase contrast- and electron-microscopy.

### 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.

### Section 4: Prokaryotic and Eukaryotic Cells: Structure and Function

**Prokaryotic Cells:** cell walls, cell membranes, mechanisms of solute transport across membranes, Flagella and Pili, Capsules, Cell inclusions like endospores and gas vesicles; Eukaryotic cell organelles: Endoplasmic reticulum, Golgi apparatus, mitochondria and chloroplasts.

### 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.

### Section 6: Control of Micro-organisms

Effect of physical and chemical agents; Evaluation of effectiveness of antimicrobial agents.

### Section 7: Microbial Metabolism

**Energetics:** redox reactions and electron carriers; An overview of metabolism; Glycolysis; Pentose-phosphate pathway; Entner-Doudoroff pathway; Glyoxalate pathway; The citric acid cycle; Fermentation; Aerobic and anaerobic respiration; Chemolithotrophy; Photosynthesis; Calvin cycle; Biosynthetic pathway for fatty acids synthesis; Common regulatory mechanisms in synthesis of amino acids; Regulation of major metabolic pathways.

### Section 8: Microbial Diseases and Host Pathogen Interaction

Normal microbiota; Classification of infectious diseases; Reservoirs of infection; Nosocomial infection; Emerging infectious diseases; Mechanism of microbial pathogenicity; Nonspecific defense of host; Antigens and antibodies; Humoral and cell mediated immunity; Vaccines; Immune deficiency; Human diseases caused by viruses, bacteria, and pathogenic fungi.

### Section 9: Chemotherapy/Antibiotics

General characteristics of antimicrobial drugs; Antibiotics: Classification, 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  $\lambda$  and its life cycle; RNA phages; RNA viruses; Retroviruses; Basic concept of microbial genomics.

### Section 11: Microbial Ecology

Microbial interactions; Carbon, sulphur and nitrogen cycles; Soil microorganisms associated with vascular plants.

## **XL - T: Zoology**

### Section 1: Animal world

Animal diversity, distribution, systematics and classification of animals, phylogenetic relationships.

### 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.

### Section 4: Biochemistry and Molecular Biology

Nucleic acids, proteins, lipids and carbohydrates; replication, transcription and translation; regulation of gene expression, organization of genome, Krebs's cycle, glycolysis, enzyme catalysis, hormones and their actions, vitamins.

### Section 5: Cell Biology

Structure of cell, cellular organelles and their structure and function, cell cycle, cell division, chromosomes and chromatin structure.

### Section 6: Gene expression in Eukaryotes

Eukaryotic gene organization and expression (Basic principles of signal transduction).

### Section 7: Animal Anatomy and Physiology

Comparative physiology, the respiratory system, circulatory system, digestive system, the nervous system, the excretory system, the endocrine system, the reproductive system, the skeletal system, osmoregulation.

### Section 8: Parasitology and Immunology

Nature of parasite, host-parasite relation, protozoan and helminthic parasites, the immune response, cellular and humoral immune response, evolution of the immune system.

### Section 9: Development Biology

Embryonic development, cellular differentiation, organogenesis, metamorphosis, genetic basis of development, stem cells.

### Section 10: Ecology

The ecosystem, habitats, the food chain, population dynamics, species diversity, zoogeography, biogeochemical cycles, conservation biology.

### 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 animal behaviour.

## **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, idly, dosa, vinegar, alcoholic beverages and sausage.

### Section 3: Food Products Technology

**Processing principles:** thermal processing, chilling, freezing, dehydration, addition of preservatives and food additives, irradiation, fermentation, hurdle technology, intermediate moisture foods. **Food pack aging and storage:** packaging materials, aseptic packaging, controlled and modified atmosphere storage. **Cereal processing and products:** milling of rice, wheat, and maize, parboiling of paddy, bread, biscuits, extruded products and ready to eat breakfast cereals. **Oil processing:** expelling, solvent extraction, refining and hydrogenation. **Fruits and vegetables 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:** psychometric, humidification and dehumidification operations.

## **Appendix F: Guidelines for conducting Exam for PwD**

**F. No. 34-02/2015-DD-III**

**Government of India**

**Ministry of Social Justice & Empowerment**

**Department of Empowerment of of Persons with Disabilities (Divyangjan)**

\*\*\*

Pt. Deendayal Antyodaya Bhawan,  
C.G.O. Complex, New Delhi -110003

Dated: the 29<sup>th</sup> August, 2018

### **Office Memorandum**

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

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

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

- I. These guidelines may be called as "Guidelines for conducting written examination for persons with benchmark disabilities 2018".
- II. There should be a uniform and comprehensive policy across the country for persons with benchmark disabilities for written examination taking into account improvement in technology and new avenues opened to the persons with benchmark disabilities providing a level playing field. Policy should also have flexibility to accommodate the specific needs on case-to-case basis.
- III. There is no need for fixing separate criteria for regular and competitive examinations.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Yours faithfully,

  
(D.K. Panda)

Under Secretary to the Government of India  
Tele. No. 24369059

To

1. Secretary of all Ministries/Department.
2. Secretary, UPSC, Shahjahan Road, New Delhi.
3. Chairman, SSC, Block No.12, CGO Complex, Lodhi Road, New Delhi-110003.
4. Chairman, University Grants Commission with a request to issue necessary instructions to all universities including Decmed Universities for compliance.
5. Chairman, Railway Board
6. All National Institutes and RCI under administrative control of Department of Empowerment of Persons with Disabilities (Divyangjan), Ministry of SJ&E, New Delhi

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

**Certificate regarding physical limitation in an examinee to write**

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

Signature

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

Name & Designation.

Name of Government Hospital/Health Care Centre with Seal

Place:

Date:

**Note:**

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

**Letter of Undertaking for Using Own Scribe**

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

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

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

(Signature of the candidate with Disability)

Place:

Date:



Information contained in this brochure is correct as on July 20, 2019. There may be changes in future due to unavoidable reasons. As and when any change happens, it will be notified on GATE 2020 website <http://gate.iitd.ac.in>

#### **IMPORTANT NOTE**

- In all matters concerning GATE 2020, the decision of the Organising Institute or the Organising Chairman, GATE 2020 will be final and binding on all the applicants.
- Although GATE 2020 is held at different centres across country, Indian Institute of Technology Delhi is organising Institute, and has the overall responsibility of conducting GATE 2020. In case of any claims or disputes arising in respect of GATE 2020, it is hereby made absolutely clear that the Delhi High Court alone shall have the exclusive jurisdiction to entertain and settle any such disputes and claims.



## Organising Institute



## Indian Institute of Technology Delhi

