

## 8. Ph.D. PROGRAMME

**Mode of Program: Regular/Part-time**

### 8.1 ELIGIBILITY

- i. A candidate seeking admission to the degree of Doctor of Philosophy must have obtained M.E./ M.Tech./ MCA/ M.Sc./ M.Com/ M.Pharma/ M.A./ M.B.A./ C.A. or equivalent with minimum CGPA of 6.00 on a 10-point scale or 60% (55% in case of SC/ST/Differently-Abled candidates) marks in aggregate where marks are awarded **OR** have qualified the GATE / CSIR-UGC NET or any other national exam conducted by the central government departments or their agencies and institutions.
- ii. Candidates with B.E./B.Tech./B.Pharma degree or equivalent with excellent academic record (minimum CGPA of 7.50 on 10-point scale or 75% marks in aggregate) may be considered for admission.

However, candidates admitted with B.E./B.Tech. or equivalent qualification will be admitted for Ph.D. after successful completion of **eight Masters level courses** as suggested by the Ph.D. Admission Committee of concerned Department/School, within a period of two years from the date of admission. A minimum CGPA of 6.00 on a 10-point scale should be earned in the courses prescribed by the concerned Department/School.

- iii. Part-time studies leading to PhD degree are permitted for TIET employees and employees of other organizations with the prior approval and no-objection certificate from their parent organization. Part-time studies leading to PhD shall also be permitted to persons working in Institutions with which a Memorandum of Understanding has been signed for research purposes. Such a candidate must be in employment at the time of admission and be engaged in professional work in the area to which admission is sought.
- iv. **Admission of a Ph.D. candidate in a Department/School other than his/her basic background:** Suitability of a candidate is the purview of admission committee, if a candidate qualifies the test and interview then he/she should be allowed to pursue Ph.D. Programme. However, the admission committee may recommend additional courses for the candidate to clear.

**NOTE: In case of Foreign Nationals applying for the Ph.D. programme, candidates need to mandatorily submit VISA permitting research work at TIET.**

## 8.2 TEACHING ASSOCIATESHIP

Category	Teaching Associateship Per Month (Rs)*	Remarks
GATE / CSIR/UGC NET or any other national exam conducted by the central government departments or their agencies and institutions	45,000	To be offered to all candidates selected with GATE/NET qualification and will be assigned with teaching load/administrative tasks and designated as Teaching Associates.
Other Candidates	30,000	To be offered to all those candidates who have qualified TIET test and will be assigned teaching load <u>as per needs of the Department/School</u> or involved in administrative tasks and will be designated as Teaching Associates.

\*Emoluments for the candidates will be paid from the date of admission.

## 8.3 ELIGIBILITY FOR TEACHING ASSOCIATESHIP

- i. Candidates will be considered for Teaching Associateship who are qualified with GATE / NET or any other national exam conducted by the central government departments or their agencies and institutions. A candidate should have minimum CGPA of 6.0 (10-point Scale) or 60% marks (55% in case of SC/ST/Differently-Abled candidates) in the qualifying exam.
- ii. PhD candidates who are not GATE/NET (UGC/CSIR) qualified may also be considered if GATE/NET (UGC/CSIR) qualified candidates are not available. Candidates, without GATE/NET (UGC/CSIR), should have minimum CGPA of 6.0 (10-point Scale) or 60% marks (55% in case of SC/ST/Differently-Abled candidates) in the qualifying exam to be eligible for Teaching Associateship.
- iii. **Duration of Associateship:** Teaching Associateships shall be awarded for a maximum period of 4 years, subject to review of performance at the end of every year. However, if a student submits his/her thesis, then Teaching Associateship will be given to him/her till the end of ongoing semester during which he/she submitted the thesis.
- iv. A research student who has been selected for the award of teaching associateship:
  - a) will be given 10-12 hours of teaching load/departmental responsibilities per week.
  - b) shall not be eligible for any other fellowship from the Institute or from any other source.

c) shall be liable to pay tuition fee and other dues as prescribed by the Institute from time to time.

v. Research students shall be eligible for contingency for attending conferences and for consumable expenses as per the rules of the Institute.

#### 8.4 GENERAL INFORMATION

TIET offers Ph.D. programme in almost all specializations of Engineering, Technology, Management and Sciences in the following Departments/Schools of the Institute (currently around **650** Ph.D. candidates are working for their Ph.D. degrees in the Institute).

Department/School	Specialization
BIOTECHNOLOGY	Microbiology/Molecular Biology
	Plant-Microbe Interactions
	Drug Discovery
	Biomaterials Nano-Technology
	Protein Engineering
CIVIL ENGINEERING	<b>Structural Health Monitoring (SHM) &amp; Retrofitting of Structures</b> <ul style="list-style-type: none"> <li>• Damage detection and real time monitoring of civil infrastructures using: i. Vibration diagnostics, ii. Ultrasonic guided waves, iii. Acoustic emission, iv. Infrared thermography, v. Digital image correlation using high speed camera.</li> <li>• Retrofitting of structures using FRP, Ferro cement and UHP-HFRC</li> <li>• High Temperature Testing of Concrete elements</li> </ul>
	<b>Structural Engineering</b> <ul style="list-style-type: none"> <li>• Passive vibration control, Seismic analysis of structures, Seismic Performance Assessment and Vulnerability Analysis of Structures</li> <li>• Wind, Reliability analysis of structures and High-speed strain loading, FEM Modelling, Reliability based design</li> <li>• Analysis of Composite Structures</li> </ul>
	<b>Sustainable Construction Materials</b> <ul style="list-style-type: none"> <li>• Self-compacting concrete, Behaviour of concrete at elevated temperatures</li> <li>• Ultra-high-performance concrete, Bacterial concrete, Rebar corrosion protection</li> <li>• Pavement Materials</li> <li>• Geo-materials.</li> </ul>
	<b>Water Resource &amp; Environmental Engineering</b> <ul style="list-style-type: none"> <li>• Contaminate transport in groundwater Water quality modelling</li> <li>• Fluvial hydraulics</li> <li>• Water resources management</li> <li>• Flood risk analysis</li> <li>• Application of remote sensing and GIS in civil and</li> </ul>

Department/School	Specialization
	environmental engineering
	<p><b>Transportation Engineering</b></p> <ul style="list-style-type: none"> <li>● Pavement Maintenance Management Systems for various categories of roads</li> <li>● Computer application for construction industry's challenges</li> <li>● Rheological properties of Paving Bitumen including modified binders</li> <li>● Mechanistic empirical structural design of pavements using various stabilized layers</li> <li>● Development of road safety methodology using sustainable design facilitating NMT and pedestrian traffic</li> <li>● Transportation planning and traffic impact studies</li> </ul>
	<p><b>Geotechnical Engineering</b></p> <ul style="list-style-type: none"> <li>● Geotechnical earthquake engineering</li> <li>● Physical modelling in geotechnics, Reinforced earth structures</li> <li>● Ground improvement techniques</li> <li>● Underground structures and Foundation Engineering</li> <li>● Geo-materials and geotextiles</li> </ul>
CHEMICAL ENGINEERING	Heat transfer and Hydrodynamics of nanofluids, Optimization.
	Thermodynamics and phase transitions of nanoconfined fluids.
	Nanomaterials, Biopolymers, Polymer-Composites and Nanocomposites, Graphene, Shear-Thickening Fluids, Microcellular Polymers and its Applications, Polymer Coatings and Thin film, Improved Impact strength and wear resistant GFRP, Drug Delivery.
	Biodegradable polymers, Porous Organic Polymers, Sorption, CO <sub>2</sub> Capture and Utilization, Modeling & Simulation.
	Heterogeneous Reaction & Catalysis, Photocatalysis, Electrocatalytic Oxidation.
	Waste water treatment, Pollution abatement, Separation processes.
	Computational Techniques in Chemical Engineering, Computational Fluid Dynamics
COMPUTER SCIENCE & ENGINEERING	Artificial Intelligence (AI)
	Cybersecurity and Cryptography
	Human-Computer Interaction (HCI)
	Algorithms and Theoretical Computer Science
	Robotics and Autonomous Systems
	Natural Language Processing
	Computer Networks and Distributed Systems
	Quantum Computing
	Green Computing

Department/School	Specialization
ELECTRONICS & COMMUNICATION ENGINEERING	Fiber Optics Communication, Networking- Wireless/ SDN/Optical, Molecular Communications, Digital Communications, Quantum-Optical Communication
	RFID Antennas, Metamaterials, UWB Antennas, Flexible Antennas, Microstrip Patch Antennas, Etc. For MIMO, Biomedical and Various Other Applications, Food Adulteration Detection, Microwave Engineering, Electromagnetic Metasurface
	Wireless Communication, Cognitive Radios, 5G/6G Communication, MIMO Systems, Wireless Sensor Networks, Wireless Network Security, Wireless Communication for IoT, Vehicular Adhoc Network, Internet of Vehicles (IOV), Vanets, Visible Light Communication, Mobile Computing (D2D Communication)
	Signal Processing, Video and Image Processing, Image & Video Forensics, Biomedical Image Processing, Biomedical Signal Processing
	Synthesis Of Nano Particles and Nano Structures, MEMS (Design and Fabrication), Semiconductor Devices and Sensors
	Nano Devices & Modelling, Nanoscale MOSFET Structure for High Scalability and Low Power Consumption, Digital, Analog & Mixed Signal Circuit Design-Automation, VLSI Architectures, VLSI Interconnects, CNT/GNR based VLSI Interconnect, Hybrid VLSI Interconnects, MEMS, Hardware Security, Low-Voltage/Low-Power Design, Device-Circuit Co-Design for IOT Applications
	Machine Learning, Deep Learning, Predictive Control, Nature Inspired Computing, Artificial Intelligence, Computer Vision, Robotics, Ai Sensors Control
	Lightweight Cryptography Algorithms, Quantum Computing, Quantum Communication and Quantum Cryptography, Cyber Security and Network Security,
	Blockchain Technology, Pervasive and Ubiquitous Computing, Cloud Computing, Edge Computing, Digital Twins Technology. Psycho Visual Image Processing, Eye Tracking Analysis, And Geomatics, Information Retrieval, Software Engineering, Optimization, Soft Computing
ELECTRICAL & INSTRUMENTATION ENGINEERING	Artificial Intelligence and its applications
	Biomedical Image Processing
	Biomedical Instrumentation
	Computer Vision
	Control Systems
	Cyber-Physical Systems
	Cyber and Information Security
	Digital Twin

Department/School	Specialization
	Energy Systems
	IoT and Embedded Systems
	Machine/Deep Learning
	Power Electronics and Drives
	Power Systems
	Process Control
	Renewable Energy
	Sensor Design and Integration
	Signal Processing
	Smart & Micro-grid, Electric Vehicles
MECHANICAL ENGINEERING	Processing, characterization, and testing of Polymer Matrix Composites, Metal Matrix Composites, Anti-corrosion coatings, Advanced High Strength Steels
	Thermal spray coating, High temperature corrosion and erosion, Super-alloys.
	Welding and joining of high strength materials such as HSLA, Nuclear Fusion Materials, Inconel super alloys. Friction stir welding and processing, Wire and Arc additive manufacturing (WAAM), Composites. Fabrication of Functionally Graded Material (FGM) via WAAM
	Alternate energy systems, Hydrogen fuel cell technology, materials for energy storage, hybrid energy systems for power applications, heat sinks and thermal management of fuel cells.
	Robotics, Automation and Controls: Mobile robot, Humanoid robot, Exoskeleton, Parallel Manipulator, Nurse robot, Underactuated systems, Modular manipulators, Fabrication and Modelling of Gantry Robot / 6-Axis Robot for 3D Printing of Concretes, Micro and Nano Robotics, Path Planning, Robots for Drug Delivery Applications, Biomimetic Robots
	Material Deformation, Mechanical Metallurgy, flexible forming techniques.
	CNC Fluid Jet Nano Polishing, Development of Automated CAD and manufacturing system for customized foot insole
	Solar energy and its application in solar desalination, solar refrigeration, solar water heating, solar pond.
	Road Accident Research, Night Driving Studies, Automobile Product Development, Nano Ceramics.
	3D printing of polymers/metals, their characterization, mechanical properties.
	Machine Intelligence for Mechanical Sciences, Prognostics and Data-driven health monitoring
	High temperature oxidation, texture, Thermo-mechanical processing, Material Characterization
	Severe plastic deformation techniques, High speed imaging, Electron Microscopy, Physical and Mechanical metallurgy of material

Department/School	Specialization
	Two phase flow, heat exchanger thermal analysis, Design optimization of copper grooved tubes used inside condenser/evaporator of room air-conditioner system
	Wave Mechanics, Elastodynamics, Wave Induced Motion, Acoustics
	Computational Fluid Dynamics Modelling of Phase Change Material, Solidification, Heat Transfer Enhancement, Heat Transfer in Porous Media, Sharklet Geometry, CFD modelling of manufacturing Processes
	MEMS, Dynamic behavior of microstructures, Dynamic performance and vibration control of MEMS, Nonlinear Behavior of FGM MEMS Beams, Dynamic Analysis of Composite Materials, Bio-MEMS, Nonlinear dynamics and shape optimization of microbeams
	Computer Assisted tool path planning for multi-axis CNC machining of large scale parametric and faceted engineering surfaces. Development of Mechatronic devices for various bio-medical applications, Development of Nobel materials for wearable sensors using advanced 3D printing applications.
	Active vibration control, Smart structures, Dynamic Analysis of FGM structures, Modelling of additive manufactured structures.
	Additive manufacturing for biomedical application, Biomedical & Biomechanics Engineering
	Dynamics and Vibration, Health monitoring
	Nonlinear dynamics, Collisions, Control
	Micro machining, Hybrid composites
	Failure and Damage Mechanics, Uncertainty Quantification, Stochastic Finite Element Analysis, Composite Structures
	Solar Thermal, Nanofluids
	Biomass gasification, dual fuel engine
	Tribology, microwave materials processing, surface engineering, FGM, Nano-lubricants
	Bio-medical Machining
	Bio-heat transfer & fluid flow
	Advanced finishing, MR-Fluids, Automation in smart manufacturing
	Bulk Powder Flow Technology
	Machine Learning, Artificial Intelligence, Industry 4.0 manufacturing systems, Predictive Maintenance, Condition Monitoring, Digital Twin
	General Noise and Vibration Engineering, Flow induced vibration, Flutter, Energy harvesting from vibration, Aero-elasticity

Department/School	Specialization
	Control Systems, Finite time control, Multiagent Systems, Sliding Mode Control
	Micro-robotics, Mobile Robotics, Path Planning, and Bio-inspired Robotics
CHEMISTRY & BIOCHEMISTRY	<b>Biochemistry</b> <ul style="list-style-type: none"> <li>● Biophysical Chemistry</li> <li>● Cancer Biology</li> <li>● Diabetes</li> <li>● Drug Development</li> <li>● Protein Misfolding</li> </ul>
	<b>Catalysis</b> <ul style="list-style-type: none"> <li>● Biocatalysis</li> <li>● Electrocatalysis</li> <li>● Nano catalysis</li> <li>● Photocatalysis</li> </ul>
	<b>Computational Chemistry</b> <ul style="list-style-type: none"> <li>● Computational aided reaction mechanism</li> <li>● Computational Catalysis</li> <li>● Computer aided drug design</li> </ul>
	<b>Materials</b> <ul style="list-style-type: none"> <li>● Nanomaterials</li> <li>● Organic Materials</li> <li>● Sustainable Materials</li> <li>● 2D functional Materials</li> <li>● Quantum Materials</li> </ul>
	<b>Sensors</b> <ul style="list-style-type: none"> <li>● Electrochemical Sensors</li> <li>● Nano Sensors</li> <li>● Organic Sensors</li> </ul>
	<b>Synthesis</b> <ul style="list-style-type: none"> <li>● Bioorganic Chemistry</li> <li>● Biotransformation</li> <li>● Medicinal Chemistry</li> <li>● Organic Chemistry</li> <li>● Supramolecular Chemistry</li> </ul>
	ENERGY & ENVIRONMENT
Valorisation of waste in construction materials, Solid waste management	
Biofuels	
Wastewater treatment technologies, Treatment Technologies for Drinking Water, Environmental Nanotechnology	
Industrial Waste Management	
Advanced Oxidation Process	
HUMANITIES AND SOCIAL SCIENCES	Human resource Management, Human Resource Development, Entrepreneurship, Educational interventions.
	Economics & Finance
	Financial Management Accounting, HR
	HR, Marketing, CSR, General Management

Department/School	Specialization
	English Literature
	Management Studies: Strategic Management and Policy, Higher Education Management, Strategic Leadership Studies, Corporate Social Responsibility (CSR), Operations Management (OM), Total Quality Management (TQM), Supply Chain Management (SCM), Sustainable & Green Marketing.
MATHEMATICS	Algebra
	Partition Theory, Combinatorics, Number Theory
	Mechanics, wave propagation
	Fuzzy Optimization
	functional Analysis
	Partial Differential Equations, Numerical Methods
	Financial Mathematics, optimization theory, Machine learning
	Application of differential equations, Mathematical modelling
	Approximation Theory, Analysis
	Technology-driven operations and performance analysis
	Astrophysics, Galactic dynamics, Remote sensing satellites and Machine Learning
PHYSICS & MATERIALS SCIENCE	Statistics
	Solid state Physics/ Materials Science/ Nuclear Physics/ Environmental radioactivity (Experimental)
	Theoretical Nuclear Physics/Particle Physics
	Condensed Matter Theory/ Computational soft condensed matter
	Non-linear dynamics

**8.5 APPLICATION FEE : Rs. 1500/-**

**8.6 SELECTION PROCESS**

- i. Candidates shall be admitted on the basis of merit of Entrance Test and Interview to be conducted by the Institute. The candidates who secure minimum of 50% (45% for SC/ST) marks in the written exam shall only be called for Interview. During interview, a candidate is required to indicate area of research.
- ii. **Relaxation for appearing in the entrance test will be given by the institute to those candidates who have qualified GATE / CSIR-UGC NET or any other national exam conducted by the central government departments or their agencies and institutions.**

**8.7 IMPORTANT DATES**

**Last date for receipt of completed application forms : July 15, 2025**

**Date for issuing the admit card through registered email ID : July 18, 2025**

### Entrance Test to be conducted by TIET

Departments	Date of Entrance Test	Time of Entrance Test
<b>Departments</b>		
Biotechnology	July 21, 2025	09:00 AM
Chemical Engineering	July 21, 2025	11:00 AM
Computer Science and Engineering	July 21, 2025	09:00 AM
Civil Engineering	July 21, 2025	01:00 PM
Electrical & Instrumentation Engineering	July 21, 2025	01:00 PM
Electronics & Communication Engineering	July 22, 2025	03:00 PM
Mechanical Engineering	July 22, 2025	09:00 AM
Physics & Materials Science	July 22, 2025	11:00 AM
Humanities & Social Sciences	July 22, 2025	09:00 AM
Mathematics	July 22, 2025	01:00 PM
Energy and Environment	July 22, 2025	01:00 PM
Chemistry & Biochemistry	July 22, 2025	03:00 PM

**Display of Result of Entrance Test : July 24, 2025**

**Dates of interview : July 25 to July 30, 2025**

**Entrance Test for Ph.D. programme shall be conducted ONLINE/OFFLINE by respective departments/schools and the candidates will be informed accordingly.**

**Admit cards will be sent to the candidates through registered email ID filled in the application form. Candidates are advised to check their email (including Junk/Spam) regularly for any updates.**

### 8.8 DURATION

The student shall submit his/her thesis to the Registrar within five years but not earlier than 3 years from the date of his/her admission.

### 8.9 COURSE WORK AFTER SELECTION TO PhD PROGRAMME

- i. Every admitted candidate (Regular/Part-time) shall have to take upto 36 credits of course work during his/her entire tenure of PhD. However, the student will be allowed to submit the research proposal after successful completion of 12-16 credits of course work that shall include at least four courses, namely,
  - a) a course on research methodology (may include quantitative methods and computer applications) or a course proposed by the Admission Committee (for those who have studied a similar course on Research Methodology at PG level),
  - b) a professional course (if not offered by any Department/ School, its syllabus to be proposed by the allocated supervisor and approved by DoAA), and
  - c) a seminar (relevant in the area of research)

- d) a course on Research and Publication Ethics
- ii. The process of registration in the course work, examination, evaluation and grading shall be same as followed for UG/PG programmes.
- iii. Only those candidates who successfully complete the course work within one year of admission and with a minimum CGPA of 6.00 on 10.00-point scale shall be registered in the Ph.D. programme.

#### **8.10 PROCESS FOR SUBMISSION OF RESEARCH PROPOSAL**

- i. After successful completion of the 12-16 credits of course work, every candidate will be required to submit research proposal, duly recommended by the Supervisor(s), December 31 shall be taken as date of completion of course work for odd semester and June 30 shall be taken as date of completion for even semester.
- ii. The minimum time period to submit the research proposal shall be one semester from the date of admission and maximum time allowed to submit the research proposal shall be one year from the date of admission.
- iii. Research proposal will be submitted to the concerned Head of the Department/School. In case of non-submission of proposal within one year, DoRDC on the recommendations of the Supervisor and Head of the Department/School may grant an extension for a maximum period of six months.
- iv. If the candidate fails to submit the proposal even during the extended period, her/his admission will be cancelled. In case the proposal is rejected by the IRB, the candidate may resubmit it within next six months starting from the date of meeting of IRB, failing which her/his admission will be cancelled.

#### **8.11 ADDITIONAL INFORMATION ON APPLICATION/SELECTION PROCESS**

- 1 For all Ph.D. programs offered by a particular department/school, single application form is required to be filled. However, if candidate want to apply for Ph.D. program of other department/school also, then he/she is required to select an additional department/school along with requisite application fee.
- 2 **If Application Fee is paid Online:** The candidates are not required to send the printout of application form but they must produce it at the time of interview.  
**If Application Fee is paid through DD:** Please send one of the printouts by attaching DD of required amount as mentioned in filled online Application Form/Prospectus (in favour of **Thapar Institute of Engineering & Technology** and payable at Patiala) to **"In-charge Admission Cell' Thapar Institute of Engineering & Technology, Patiala (Punjab)-147 004.**
- 3 The policy of UGC guidelines regarding reservation of seats for SC/ST and Physically Challenged candidates shall be followed.
- 4 No separate intimation will be sent regarding conduct of Entrance Exam, Interview and start of session.

- 5 In case of a tie among candidates securing equal marks in the merit list, the same will be broken in accordance with the following criteria:
- Candidate senior in age shall rank higher in order of merit.
  - In the case of a tie in age also, a candidate getting higher percentage of marks in the qualifying examination shall be ranked higher in order of merit.
  - In the case of a tie in percentage of marks in the qualifying examination also, a candidate securing higher percentage of marks in matriculation/secondary or equivalent examination shall rank higher in order of merit.
- 6 Candidates appearing in the final exam of the qualifying degree are also eligible to apply. Such candidates have to furnish following undertaking at the time of counselling.
- "I am applying on my own risk and responsibility as my final result of the Qualifying Exam has not been declared.*
- I do hereby declare that I do not have any backlog paper in any of the previous semesters (Years) of study of the qualifying exam and also, I do not expect any backlog in my final exam.*
- I assure you that I will produce the proof of passing of my Qualifying Examination with the minimum percentage of marks required on or before **December 31, 2025**, failing which my admission shall stand cancelled and I shall not claim any right on any count whatsoever."*
- 7 The students who qualify the entrance tests of the following Departments/Schools are also eligible for appearing in interview for Ph.D. admission in Chemical Engineering
- Department of Mechanical Engineering
  - Department of Biotechnology
  - Department of Chemistry and Biochemistry
  - Department of Environment and Energy

## **8.12 INSTRUCTIONS FOR ENTRANCE TEST**

- 1 Entrance Test for Ph.D. programme shall be conducted ONLINE by respective departments/schools.
- 2 The Admit Cards for entrance test shall be sent to registered email IDs (as mentioned in online application form) of the candidates provided their DD along with print out of application form reaches Thapar Institute of Engineering & Technology within the stipulated time, in case application fee paid through DD.
- Note: The Admit Card shall be issued provisionally to the candidate subject to his/her satisfying the eligibility condition.**
- 3 The Entrance Test shall contain 80 objective type questions. Duration of the Entrance Test will be 90 minutes.
- 4 The total marks of the test will be 80.

- 5 The test will consist of 50% of Research Methodology, and 50% shall be subject specific.
- 6 Cut off marks in the entrance test will be 50% (45% for SC/ST) of the total marks. The merit list will be prepared by assigning 70% to the entrance test and 30% to the performance in the interview.
- 7 There will be no negative marking in the test.

### **Ph.D. Entrance Examination Syllabus**

#### **DEPARTMENT OF BIOTECHNOLOGY**

##### **Part A: Research Methodology (50% weightage)**

**Mental ability and aptitude, biostatistics and biomathematics:** Basic aptitude and reasoning, determinants and matrices, fundamentals of statistics, Measures of central tendencies and dispersion, probability and distributions, hypothesis testing, Z, t-test, two sample test, ANOVA, Tukey test, non- parametric tests, chi-square test, correlation and regression, Applications of statistics in biology, definitions (populations, samples), Basic concepts, types of data.

**Literature Search:** Use of Databases for literature search, Bibliometrics, Citation, Impact factor.

**Good Laboratory Practices:** Safety measures, Handling and storage of biological material, Aseptic techniques, Laboratory waste disposal, Management of personnel, facilities, buildings and equipment.

**Introduction to Intellectual Property Rights,** Types of IP, Patent search, IP management.

##### **Basic Techniques in Biotechnology:**

Microscopy: Bright field, phase contrast, fluorescence, confocal, and electron microscopy, staining techniques.

Chromatography: Ion exchange, Gel Filtration, TLC, HPLC, Affinity chromatography.

UV/Vis spectrophotometry: Beer-Lambert's law and its use in determination of protein/nucleic acid concentration, standard curve.

Centrifugation: Sedimentation coefficient, g value, RPM, density gradient centrifugation. Separation of sub-cellular components and macromolecules using high speed and ultracentrifugation.

Electrophoresis: Native and SDS-PAGE, Isoelectric focusing, 2D-PAGE and its applications.

Fluorescence Spectroscopy: Basic concepts of excitation and emission, Fundamentals of CD, IR and Raman spectroscopy and their use in the study of

biomolecular conformation, X-ray, NMR and cryo-electron microscopy for determination of biomolecular structure.

**Part B: Subject-specific content (50% weightage)**

**Microbiology:** Classification of microorganisms, microbial growth and nutrition, microbial physiology, preservation and control of microorganisms, microbial diseases, microbial genetics

**Genetics:** Mendelian genetics, patterns of inheritance – incomplete dominance, multiple alleles, co-dominance, lethal genes, polygenic inheritance, sex linked inheritance, cell division, chromosomal structure and genetic material

**Biochemistry:** Biomolecules- structure and function, intra- and intermolecular forces, bioenergetics, biochemical equilibria, signal transduction and regulation, metabolism of carbohydrates, lipids, proteins and nucleic acids and biochemical techniques.

**Molecular biology and genetic engineering:** DNA replication in prokaryotes and eukaryotes, DNA damage and repair, recombination, Transcription and translation in prokaryotes and eukaryotes, RNA processing, genetic code, post-translational modifications, transfer of genetic material in microorganism, gene silencing, oncogenes, genetic disorders, apoptosis, DNA modifying enzymes, molecular cloning, cloning & expression vectors, genomic & cDNA libraries, recombinant gene expression & its applications and molecular techniques.

**Plant biotechnology:** Plant tissue culture, micropropagation, production of haploid plants, embryo culture, soma clonal variations, germplasm conservation, manipulation of phenotypic traits by recombinant DNA technology, plant vectors and methods of DNA transfer, generation of transgenic plants and their applications

**Animal biotechnology and Immunology:** Mammalian cell culture, culturing types, types of media, viability assay, contamination and cryopreservation, transgenic animals and animal cloning, gene therapy, stem cells and their application, Innate and adaptive immunity, Cells of immune systems, humoral and cell mediated immunity, complement systems, cytokines, MHC, antigen & antibody and their interactions, immunological techniques, autoimmunity, hypersensitivity and immunodeficiency, immune response to infectious diseases, cancer and transplantation and vaccines.

**Bioinformatics:** Biological databases, biological sequence formats, pairwise sequence alignment – methods and algorithms, FASTA, BLAST, multiple sequence alignment and phylogenetics, structural bioinformatics, Ramachandran plot, protein secondary and tertiary structure prediction methods and algorithms and homology modeling

**Environmental Biotechnology:** Ecology, environmental pollution and control, bioprocesses in controlling pollution, biomonitoring and biosensors.

**Enzymology and bioprocess technology:** Enzyme classification and nomenclature, enzyme kinetics & mechanism, activators and inhibitors, regulation of enzyme activities, sterilization concepts in fermentation, cell growth and kinetics, bioreactor studies, aeration & agitation and downstream processing.

## **CHEMICAL ENGINEERING DEPARTMENT**

### **Subject-specific section**

- First and second laws of thermodynamics and their applications, real gas equation of states, phase equilibria, chemical reaction equilibria
- Material and energy balances
- Flow through pipes, flow measuring devices, pumps, two phase flow, packed and fluidized bed
- Heat transfer processes, heat transfer coefficients and equipment
- Diffusion, absorption, adsorption, distillation, extraction, transport analogies
- Kinetics of homogeneous reactions, interpretation of kinetic data, residence time distribution, kinetics and reactor design for heterogeneous reactions
- Instrumentation and process control
- Chemical process industries

### **Research methodology section**

- Meaning & features of research methodology, motives & types of research, attributes of good research, selection of thrust research
- Statistical analysis and measure of central tendency and dispersion, mean, median, mode, range, mean deviation and standard deviation
- Formulation of hypothesis, characteristics and concepts relating to testing of hypothesis (parameter and statistic, standard error, level of significance, type-I and type-II errors, critical region, one tail and two tail tests), procedure of testing hypothesis, T and chi-square distribution, analysis of variance
- Linear regression, least square analysis. Karl Pearson's correlation coefficient, Rank coefficient, lines of regression.
- Data analysis & interpretation, multiple and partial correlation, multiple regression analysis (with two independent variables), specification of regression models and estimation of parameters, interpretation of results
- Guidelines & strategies for design of experiments, factorial experimental design, designing engineering experiments, basic principles-replication, randomization and blocking

## **CIVIL ENGINEERING DEPARTMENT**

NOTE: There are TWO sections in the syllabus:

**Section 1: RESEARCH METHODOLOGY** (Compulsory)

**Section 2: SUBJECT SPECIFIC CONTENT** (This section has 5 Sub-section)

- i. Surveying
- ii. Structural Engineering
- iii. Geotechnical Engineering
- iv. Water Resource and Environmental Engineering
- v. Transportation Engineering

A candidate must attempt 80 compulsory questions. There will be 50% questions from Section 1 and 50% from the Section 2. In the Section2, Sub-section 1 (Surveying) is compulsory; however, candidates can choose any one from Sub-sections 2 – 5 (i.e., Structural Engineering; Geotechnical Engineering; Water Resource and Environmental Engineering; Transportation Engineering) as per their area of interest or Master's degree specialization.

## **Section 1: RESEARCH METHODOLOGY**

Meaning and characteristics of research, Methods of Research; Ethics in Research. Statistics in research: Percentages, Frequency distribution, Averages, Measures of Central tendency, Arithmetic mean, Median, Mode, Geometric Mean, Harmonic Mean, Median, Dispersion, Range, Mean Deviation, Standard deviation, Root mean square deviation, Variance.

Sampling and Data Analysis: Observation and collection of data, diagrammatic & graphical presentation of data; Sampling methods - Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis - Cross tabulations, etc. Correlation- Time series analysis, multivariate techniques, regression. Hypothesis testing: parametric and nonparametric tests (chi square, t-test, two tailed tests, one tailed test, etc.)

## **Section2: SUBJECT SPECIFIC CONTENT**

### **Sub-section 1: SURVEYING (Compulsory)**

Levelling and contour, theodolite traversing, plane table surveying, Principles of total station, GPS survey, concepts of remote sensing

### **Sub-section 2: STRUCTURAL ENGINEERING (Optional)**

**Strength of materials:** Bending moment and shear force in statically determinate beams. Simple stress and strain relationship. Simple bending theory, flexural and shear stresses, uniform torsion, buckling of column, combined and direct bending stresses.

**Structural Analysis:** Analysis of statically determinate trusses, arches, beams, cables and frames, displacements in statically determinate structures (Macaulay's double integration method, moment area theorem, conjugate beam method, unit load method and Castigliano's theorem) and analysis of statically indeterminate structures by force/ energy methods (Method of Consistent Deformations and Three Moment Theorem), analysis by displacement methods (slope deflection and moment distribution methods), influence lines for determinate.

**Concrete Structures:** Concrete Technology- properties of concrete, mix design as per IS 10262:2019. Concrete design- basic working stress and limit state design concepts, design of members subjected to flexure, shear, compression and torsion by limit state methods. Design and reinforcement detailing of building frames. Basic elements of prestressed concrete, analysis of beam sections at transfer and service loads. Fundamentals of earthquake, IS1893: 2016 and IS 13920:2016 concepts.

**Steel Structures:** Analysis and design of tension and compression members, column bases. Connections- simple and eccentric, design of welded and bolted joints (lap joint, butt joint), beam-column connections

### **Sub-section 3: GEOTECHNICAL ENGINEERING(Optional)**

**Soil Mechanics:** Origin of soils, soil classification, three-phase system, fundamental definitions, phase relationships, clay minerals, permeability, seepage, effective stress principle, capillarity, stress due to surface load, compaction, consolidation, shear strength.

**Foundation Engineering:** Sub-surface investigations- scope, drilling bore holes, sampling, penetration tests, plate load test. Earth pressure theories, effect of water table, layered soils, backfill inclination. Stability of retaining walls, MSE walls. Stability of slopes - infinite slopes, finite slopes, method of slices, total stress analysis, sudden drawdown condition. Foundation types - foundation design requirements. Shallow foundations-bearing capacity, effect of shape, water table and other factors, stress distribution, settlement analysis in sands & clays. Deep foundations-pile types, dynamic & static formulae, load capacity of piles in sands & clays, negative skin friction.

### **Sub-section 4: WATER RESOURCES & ENVIRONMENTAL ENGINEERING(Optional)**

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

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

**Hydrology:** Hydrologic cycle, precipitation, evaporation, evapo-transpiration, infiltration, unit hydrographs, hydrograph analysis, reservoir capacity, discharge measurement in rivers, peak flood estimation, flood routing, ground water hydrology - steady state well hydraulics and aquifers; Application of Darcy's Law.

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

#### **Water and Waste Water Quality and Treatment:**

Basics of water quality standards – Physical, chemical and biological parameters; Water quality index; Unit processes and operations; Water requirement; Water distribution system; Drinking water treatment. Sewerage system design, primary and secondary treatment. Effluent discharge standards; Sludge disposal; Reuse of treated sewage for different applications.

**Basics of remote sensing and GIS:** EM spectrum, signatures, errors, Image classification, map, and projection system.

### **Sub-section 5: TRANSPORTATION ENGINEERING(Optional)**

**Highway Infrastructure:** Geometric design of highways, testing and specifications of paving materials, design of flexible and rigid pavements as per IRC codes.

**Traffic Engineering:** Traffic characteristics, theory and parameters of traffic flow, types of intersection, traffic signs and signal design, highway capacity.

**Construction Management:** Types of contracts, project planning and network analysis - CPM and PERT, estimation, and costing.

## COMPUTER SCIENCE AND ENGINEERING DEPARTMENT

### Section A:

*Probability:* Sample space, events, relative frequency and axiomatic definitions of probability, addition rule and conditional probability, multiplication rule, total probability, Baye's Theorem.

*Random Variables:* Discrete, continuous and mixed random variables, probability mass, probability density and cumulative distribution functions, mathematical expectation, moments, probability and moment generating function, median and quantiles, Markov inequality, Chebyshev's inequality, Function of a random variable.

*Special Distributions:* Discrete uniform, binomial, geometric, negative binomial, Poisson, continuous uniform, exponential, gamma, normal, lognormal, inverse Gaussian, Cauchy, double exponential distributions, reliability of series and parallel systems.

*Joint Distributions:* Joint, marginal and conditional distributions, product moments, correlation and regression, independence of random variables, bivariate normal distribution.

*Sampling Distributions:* The Central Limit Theorem, distributions of the sample mean and the sample variance for a normal population, Chi-Square, t and F distributions.

*Estimation:* Unbiasedness, consistency, the method of moments and maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems of normal populations, confidence intervals for proportions.

*Testing of Hypotheses:* Null and alternative hypotheses, the critical and acceptance regions, two types of error, power of the test, Neyman-Pearson Fundamental Lemma, tests for one sample and two sample problems for normal populations, tests for proportions, Chi-square goodness of fit test and its applications

### Section B:

*Introduction to programming:* C Functions, Loops, Arrays and Pointers, Strings, Structures and Unions, file input/output, and formatted I/O, Dynamic memory allocation, Preprocessor directives, Bitwise operations and bit fields, mathematical functions, time and date functions, string handling functions, typecasting, type conversions, and type compatibility, Error handling.

*Introduction to OOP:* Class design and object-oriented modelling, Abstraction, encapsulation, data hiding, Inheritance and polymorphism, Exception handling, Collections: lists, sets, maps, and dictionaries.

*Data Structure and Algorithm Analysis:* Stack, Queue, Linked List, Tree, Graph, Searching, Sorting & Hash Faction, Algorithm Analysis, Brute Force and Exhaustive Search Algorithms, Divide and Conquer Algorithms, Greedy Algorithms, Dynamic Programming, Backtracking , Branch and Bound, Randomized Algorithms, Complexity Theory and NP-Completeness,

*Operating Systems:* System Structures, Process Management and CPU Scheduling, Threads, Deadlock, Memory Management, File Systems, Disk Management, Protection and Security, Concurrency.

*Database Management System:* Introduction to Database Systems, Data Models, SQL (Structured Query Language), Relational Database Design, Transaction Management, Storage and Indexing, Database Security, Data Warehousing and Data Mining, NoSQL databases and Big Data.

*Computer Networks:* Physical Layer, Data Link Layer, Network Layer, Transport Layer & Application Layer.

## ELECTRONICS & COMMUNICATION ENGINEERING DEPARTMENT

### Section A: Research methodology

#### Foundations of Research

- Meaning, Objectives, and Importance of Research.
- Types of Research: Basic, Applied, Qualitative, Quantitative, Experimental, and Descriptive.
- Characteristics of Good Research.
- Research Process: Steps in Research (Problem Identification, Review of Literature, Objectives).
- Hypothesis: Definition, Characteristics, Types, and Testing.

#### Literature Review

- Role and Importance of Literature Review in Research.
- Sources of Literature: Journals, Books, and Databases.
- Referencing and Citation Styles (APA, MLA, IEEE, Chicago).
- Plagiarism: Concepts, Detection, and Ethical Considerations.

#### Research Design and Methods

- Types of Research Designs: Exploratory, Descriptive, and Experimental.
- Case Study and Action Research.
- Data Collection Methods:
- Primary Data: Surveys, Interviews, and Questionnaires.
- Secondary Data: Literature and Archival Research.
- Tools for Data Collection: Observations and Focus Groups.

#### Data Analysis and Interpretation

- Basics of Statistical Analysis: Mean, Median, Mode, Standard Deviation, and Variance.
- Hypothesis Testing: t-Test, Chi-square, and ANOVA (Concepts Only).
- Use of Software for Quantitative Analysis (e.g., SPSS, MATLAB, R).
- Qualitative Data Analysis:
- Thematic and Content Analysis.
- Coding and Categorization in Research.

#### Report Writing and Presentation

- Structure of Research Reports: Abstract, Introduction, Methodology, Results, and Discussion.
- Techniques for Writing Research Papers for Journals and Conferences.
- Preparing Oral and Poster Presentations.

#### Ethical Considerations in Research

- Research Ethics: Integrity, Confidentiality, and Professional Conduct.
- Intellectual Property Rights (IPR): Patents, Copyrights, and Trademarks.

#### Emerging Trends in Research

- Multidisciplinary Research Approaches.
- Role of AI, Machine Learning, and Big Data in Modern Research.
- Open Access Journals and Preprint Servers.

### Section B: Subject Specific

**Networks:** Node and mesh analysis, superposition, Thevenin's theorem, Norton's theorem, reciprocity, RL, RC and RLC circuits, solution of network equations using Laplace transform, basic control system components.

**Signal and Systems:** Fourier series and Fourier transform, sampling theorem and applications. Discrete-time Signals: DTFT, DFT, z-transform, discrete-time processing

of continuous-time signals. LTI systems: definition and properties, causality, stability, impulse response, convolution, poles and zeroes, frequency response, group delay, phase delay.

**Electronic Devices and Circuits:** Energy bands in semiconductors, equilibrium carrier concentration, direct and indirect band-gap semiconductors. Carrier Transport, P-N junction, types of diodes, BJT, MOS capacitor, MOSFET and CMOS.

**Digital Circuits:** Digital circuits: Boolean algebra; minimization of Boolean functions: logic gates, digital IC families (DTL, TTL, ECL, MOS, CMOS). Combinational circuits, Sequential circuits: latches and flip-flops, counters and registers, Microprocessors: evolution, microcomputer architecture, Intel 8085/8086: architecture, addressing mode, instruction set, programming technique, interrupt structure, RISC and CISC, Memory Hierarchy.

**Computing:** ability to write programs to solve simple problems, use of elementary data structures such as arrays, lists, stacks, queues, trees, familiarity with recursion, ability to reason about programs, loop invariants and assertions.

**Communications:** Analog Communications: amplitude modulation and demodulation, angle modulation and demodulation, spectra of AM and FM, super heterodyne receivers. Digital communications: PCM, DM, digital modulation schemes (ASK, PSK, FSK).

**Electromagnetics:** Maxwell's Equations: Differential and integral forms and their interpretation, boundary conditions, wave equation, Poynting vector, Transmission Lines, Plane Waves and Properties.

## ELECTRICAL ENGINEERING

**Electric Circuits and Fields:** Network graph, KCL, KVL, node and mesh analysis, transient response of dc and ac networks; sinusoidal steady-state analysis, resonance, basic filter concepts; ideal current and voltage sources, Thevenin's, Norton's and Superposition and Maximum Power Transfer theorems, two-port networks, three phase circuits; Gauss Theorem, electric field and potential due to point, line, plane and spherical charge distributions; Ampere's and Biot-Savart's laws; inductance; dielectrics; capacitance.

**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; Fourier, Laplace and Z transforms.

**Electrical Machines:** Single phase transformer – equivalent circuit, phasor diagram, tests, regulation and efficiency; three phase transformers – connections, parallel

operation; auto-transformer; energy conversion principles; DC machines – types, windings, generator characteristics, armature reaction and commutation, starting and speed control of motors; three phase induction motors – principles, types, performance characteristics, starting and speed control; single phase induction motors; synchronous machines – performance, regulation and parallel operation of generators, motor starting, characteristics and applications; servo and stepper motors.

**Power Systems:** Basic power generation concepts; transmission line models and performance; cable performance, insulation; corona and radio interference; distribution systems; per-unit quantities; bus impedance and admittance

matrices; load flow; voltage control; power factor correction; economic operation; symmetrical components; fault analysis; principles of over-current, differential and distance protection; solid state relays and digital protection; circuit breakers; system stability concepts, swing curves and equal area criterion; HVDC transmission and FACTS concepts.

**Control Systems:** Principles of feedback; transfer function; block diagrams; steady-state errors; Routh and Nyquist techniques; Bode plots; root loci; lag, lead and lead-lag compensation; state space model; state transition matrix, controllability and observability.

**Power Electronics and Drives:** Semiconductor power diodes, transistors, thyristors, triacs, GTOs, MOSFETs and IGBTs – static characteristics and principles of operation; triggering circuits; phase control rectifiers; bridge converters – fully controlled and half controlled; principles of choppers and inverters; basic concepts of adjustable speed dc and ac drives.

### **Research Methodology**

The syllabus covers the fundamentals of research, including the definition, importance, and various types (qualitative, quantitative, and mixed-methods), as well as the research process involving problem identification, literature review, hypothesis formulation, data collection, analysis, and conclusion. This also includes research design and methodology, highlighting experimental and non-experimental designs, data collection methods like surveys and interviews, data analysis techniques, and sampling approaches. The syllabus covers research ethics, intellectual property rights, plagiarism, and academic integrity. It also focuses on research writing, exploring the structure of reports, referencing styles (APA, MLA, IEEE), and the use of visuals in communication. Finally, case studies and real-world applications are included to illustrate the practical use of research methodology.

## **ELECTRONICS (INSTRUMENTATION & CONTROL) ENGINEERING**

**Instrumentation Engineering Basics of Circuits and Measurement Systems:** Kirchoff's laws, mesh and nodal Analysis. Circuit theorems. One-port and two-port Network Functions. Static and dynamic characteristics of Measurement Systems. Error and uncertainty analysis. Statistical analysis of data and curve fitting.

**Transducers, Mechanical Measurement and Industrial Instrumentation:** Resistive, Capacitive, Inductive and piezoelectric transducers and their signal conditioning. Measurement of displacement, velocity and acceleration (translational and rotational), force, torque, vibration and shock. Measurement of pressure, flow, temperature and liquid level. Measurement of pH, conductivity, viscosity and humidity.

**Analog Electronics:** Characteristics of diode, BJT, JFET and MOSFET. Diode circuits. Transistors at low and high frequencies, Amplifiers, single and multi-stage. Feedback amplifiers. Operational amplifiers, characteristics and circuit configurations. Instrumentation amplifier. Precision rectifier. V-to-I and I-to-V converter. Op-Amp based active filters. Oscillators and signal generators.

**Digital Electronics:** Combinational logic circuits, minimization of Boolean functions. IC families, TTL, MOS and CMOS. Arithmetic circuits. Comparators, Schmitt trigger, timers and mono-stable multi-vibrator. Sequential circuits, flip-flops, counters, shift registers. Multiplexer, S/H circuit. Analog-to-Digital and Digital-to-Analog converters. Basics of number system. Microprocessor applications, memory and input-output interfacing. Microcontrollers.

**Signals, Systems and Communications:** Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first- and second order systems. Convolution, correlation and characteristics of linear time invariant systems. Discrete time system, impulse and frequency response. Pulse transfer function. IIR and FIR filters. Amplitude and frequency modulation and demodulation. Sampling theorem, pulse code modulation. Frequency and time division multiplexing. Amplitude shift keying, frequency shift keying and pulse shift keying for digital modulation.

**Electrical and Electronic Measurements:** Bridges and potentiometers, measurement of R, L and C. Measurements of voltage, current, power, power factor and energy. AC & DC current probes. Extension of instrument ranges. Q-meter and waveform analyzer. Digital voltmeter and multi-meter. Time, phase and frequency measurements. Cathode ray oscilloscope. Serial and parallel communication. Shielding and grounding.

**Control Systems and Process Control:** Feedback principles. Signal flow graphs. Transient Response, steady-state-errors. Routh and Nyquist criteria. Bode plot, root loci. Time delay systems. Phase and gain margin. State space representation of systems. Mechanical, hydraulic and pneumatic system components. Synchro pair, servo and step motors. On-off, cascade, P, P-I, P-I-D, feed forward and inferential controller, Fuzzy controllers.

**Analytical, Optical and Biomedical Instrumentation:** Mass spectrometry. UV, visible and IR spectrometry. X-ray and nuclear radiation measurements. Optical sources and detectors, LED, laser, Photo-diode, photo-resistor and their characteristics. Interferometers, applications in metrology. Basics of fibre optics. Biomedical instruments, EEG, ECG and EMG. Clinical measurements. Ultrasonic transducers and Ultrasonography. Principles of Computer Assisted Tomography.

### **Research Methodology**

The syllabus covers the fundamentals of research, including the definition, importance, and various types (qualitative, quantitative, and mixed-methods), as well as the research process involving problem identification, literature review, hypothesis formulation, data collection, analysis, and conclusion. This also includes research design and methodology, highlighting experimental and non-experimental designs, data collection methods like surveys and interviews, data analysis techniques, and sampling approaches. The syllabus covers research ethics, intellectual property rights, plagiarism, and academic integrity. It also focuses on research writing, exploring the structure of reports, referencing styles (APA, MLA, IEEE), and the use of visuals in communication. Finally, case studies and real-world applications are included to illustrate the practical use of research methodology.

## MECHANICAL ENGINEERING DEPARTMENT

Candidates can choose to attempt questions from any one of the first four main sections, (i) Mechanical Design, or (ii) Manufacturing Processes, or (iii) Thermal-Fluid Engineering, or (iv) Control system, Instrumentation, Automation, Robotics & AI. Questions from the last section (section v: Research Methodology) will be compulsory for all.

### **i. Mechanical Design**

Engineering Mechanics: Resultant of forces, free-body diagrams and equilibrium of particle and rigid bodies; trusses and frames; friction; centroid and second moment of area.

Strength 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.

Machine Design: Design for static and dynamic loading; failure theories; fatigue strength; principles of the design of machine elements such as bolted, riveted and welded joints; shafts, gears.

Theory of Machines: Plane mechanisms, dynamic analysis of linkages; cams; gears and gear trains; flywheels; balancing of reciprocating and rotating masses, velocity and acceleration diagrams.

Vibrations: Free and forced vibration of single degree of freedom systems, effect of viscous and Coulomb damping; vibration isolation; resonance, natural frequency and mode shapes.

Basics of mechatronics and control systems, robotics, vehicle dynamics.

OR

### **ii. Manufacturing Processes**

Metal Casting: Casting processes – types and applications; patterns – types and materials; allowances; moulds and cores; permanent-mold casting, die casting, cold-chamber and hot-chamber die casting, centrifugal casting.

Metal Forming: Hot and cold working – forging, rolling, extrusion, wire and tube drawing; sheet metal working processes such as blanking, piercing, bending, deep drawing, coining and embossing.

Metal Joining Processes: Welding processes – manual metal arc, MIG, TIG, plasma arc, submerged arc, thermit, resistance, friction, other joining processes – soldering and brazing.

Basic Machining and Machine Tool Operations: Machine tools; machining processes-turning, drilling, boring, milling, shaping, planing, grinding, geometry of cutting tools, chip formation, tool materials, cutting fluids and their functions; principles of non-traditional machining processes – USM, AJM, WJM, EDM, LBM, CHM, ECM.

OR

### **iii. Thermal-Fluid Engineering**

Thermodynamics: Thermodynamic laws, properties, path and point functions, energy equation, heat engine and refrigeration cycles, entropy change due to heating and cooling, entropy generation, thermodynamic property diagrams, different cycles with advanced arrangements: Rankine, gas turbine, Otto, Diesel, vapour compression, vapour absorption, combined cycles, psychometric properties

Fluid Mechanics and Fluid Machinery: Types of fluids and flows, viscosity, pressure distribution in static fluid systems, velocity and shear stress distribution for fluids in motion, laminar and turbulent flow, dimensionless numbers, pressure drop in laminar, turbulent flows, series and parallel pipe flow, boundary layer formation, drag and lift forces, compressible flow, flow through nozzles and diffusers, velocity diagrams and performance of turbines, pumps and compressors and characteristic curves

I.C. Engines: Different types of efficiencies, combustion stages, knocking, engine testing and performance.

Heat Transfer: Fourier law of heat conduction, thermal resistance in conduction, convection and radiation in series and parallel, critical radius of insulation, black body radiation, heat exchangers.

**OR**

#### **iv. Control system, Instrumentation, Automation, Robotics & AI**

Control System: Mathematical modeling of dynamic systems, Transfer function and state-space representation, Time response analysis: transient and steady-state response, Root locus, Bode plots, Routh-Hurwitz and Nyquist criteria for stability, PID controllers, lead-lag compensators, controllability, observability, Pole placement and state feedback design, State observer design, Linear quadratic regulator (LQR) and Kalman filters, Lyapunov stability, Feedback linearization

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), temperature (thermocouple, bolometer, RTD (3/4 wire), thermistor,); 4-20 mA two-wire transmitter.

Robotics: Coordinate frames and their transformation: rotary and homogeneous, degrees of freedom, different types of joint pairs such as prismatic joint, revolute joint, spherical joint, etc., workspace, work envelope and singularities of a manipulator, Denavit Hartenberg algorithm.

Artificial Intelligence: Introduction: Supervised and Unsupervised learning. Data pre-processing. Under fitting and over fitting, Regression: Simple and Multiple Linear Regression, Classification: Random Forest classification, K-Nearest Neighbours (K-NN), Support Vector Machine (SVM), Basics of ANN and CNN. Structure of neurons and ANN model. CNN structure and importance of different layers.

#### **v. Research Methodology (Compulsory Section)**

Introduction to Statistical Analysis: measures of central tendency and dispersion, mean, median, mode, range, mean deviation, standard deviation, coefficient of variation. Linear Regression and Correlation: linear regression, least square principle and fitted models. Design of Experiments. Calculus: limits, derivatives, and functions, Integral calculus. Differential Equations: ordinary and partial. Simultaneous Equations. Matrices and Determinants: addition and multiplication. Stress-strain curve for ductile and brittle materials. First, second, and third law of thermodynamics. Tool materials and tool signature.

### **DEPARTMENT OF CHEMISTRY AND BIO-CHEMISTRY**

#### **RESEARCH METHODOLOGY IN CHEMISTRY**

##### **1. Fundamentals of Research Methodology**

Meaning and Objectives of Research, Types of Research: Fundamental, Applied, Experimental, Analytical, Scientific Research Process: Hypothesis, Experimentation, Analysis, Research Ethics and Plagiarism

## 2. Experimental Design Optimization

**Error Analysis in Scientific Research:** Understanding accuracy, precision, and different types of errors, **Error Classification and Reduction Strategies:** Identification, minimization, and compensation of errors, **Significant Figures and Data Computation:** Rules for determining significant figures, mean deviation, and standard deviation calculations, **Statistical Error Handling:** Propagation of errors in calculations, confidence intervals, and estimation of confidence limits for known and unknown sigma values, **Probability and Statistical Distributions:** Properties of Gaussian distribution and its applications in research, **Significance Testing in Data Analysis:** Understanding and applying statistical tests such as Student's t-test, F-test, and Q-test, **Graphical Data Representation:** Effective methods for data visualization, constructing and interpreting graphs, and using least squares fitting, **Introduction to Chemometrics:** Application of statistical and mathematical techniques for optimizing experimental outcomes

### Recommended Books:

"Principles of Instrumental Analysis", D. A. Skoog, F. James Hollier and S. R. Crouch, 6th edn., Thomson Brooks/Cole Publishers (2007).

## 3. Instrumentation Techniques for Chemistry Research

Chromatographic techniques: HPLC, GC-MS, Thermal analysis techniques: TGA, DSC, Electrochemical analysis and microscopy (SEM, TEM, XRD)

## 4. Interpretative Spectroscopy

Structure elucidation of some model organic molecules by UV-Vis, IR, <sup>1</sup>H NMR, <sup>13</sup>C NMR and MS.

### Recommended Books:

Pavia, D.L., Lampman, G.M., and Kriz, G.S., Introduction to Spectroscopy, Brooks/Cole Cengage Learning (2008) 4th ed.

### NPTEL Link:

<https://archive.nptel.ac.in/content/storage2/courses/104103071/pdf/mod9.pdf>  
<https://www.youtube.com/watch?v=nY0em0eQY7Q>

## PHYSICAL CHEMISTRY

### 1. Quantum Chemistry

Basic principles and applications of quantum mechanics, Postulates of quantum mechanics, State of a system, Probability amplitude, Probability density, Operators and observables, Eigen function and Eigen value, Hermitian operators, Commutators, Expectation value. Schrodinger equation to some model systems viz., Particle in a box, Harmonic Oscillator, The Rigid Rotor, The hydrogen atom.

### Recommended Book:

Levine, N.I., Quantum Chemistry, Prentice Hall (2008) 5th ed.

### NPTEL Link:

<https://youtube.com/playlist?list=PLbMVogVj5nJRiUhnP3bleX5Kp3ljZaX1C&si=MGmL84HdBcbbc17qt>

## 2. Molecular Spectroscopy

Electromagnetic radiation, Interaction of electromagnetic radiation with matter, Energies of atomic and molecular orbitals, UV-Visible spectroscopy, Vibrational Spectroscopy, Rotational Spectroscopy, Raman Spectroscopy, Magnetic Resonance Spectroscopy, Electron Spin Resonance Spectroscopy.

### Recommended Book:

Donald L. Pavia, Introduction to Spectroscopy, 5th Edition.

### NPTEL Link:

<https://www.youtube.com/watch?v=g2sqX3FkcRo&list=PL0zRYVm0a65eCqECeSQJwmKX6D4zibX84>

## 3. Thermodynamics and Chemical Kinetics

**Classical Thermodynamics:** Concepts involved in first, second and third law of thermodynamic, Free energy and entropy of mixing, Partial molar quantities, Gibbs-Duhem equation. Equilibrium constant, Temperature-dependence of equilibrium constant, Thermodynamic description of phase transitions, Determination of activity and activity coefficient by Debye Huckel law.

### Reaction Kinetics:

Introduction, Rates of chemical reactions, Methods of determining rate laws, Mechanisms of chemical reactions and steady state approximation, Chain and oscillatory reactions, Collision and transition state theories, Stearic factor, unimolecular and bimolecular surface reactions, Homogeneous and heterogeneous catalysis, enzyme catalysis. Effect of pressure on reaction rate, Kinetics of catalytic reactions, adsorption, Estimation of surface area (BET equation).

### Recommended Books:

Kapoor, K.L., A Text Book of Physical Chemistry, Vol. 3, Macmillan India (2005) 2nd ed.

Atkins, P.W., Physical Chemistry, W.H. Freeman (1990).

### NPTEL Link:

[https://www.youtube.com/watch?v=Ce9X4A7b94Q&list=PLI13zV64b7xRSd\\_iewlSMruH0PcwKXUjQ](https://www.youtube.com/watch?v=Ce9X4A7b94Q&list=PLI13zV64b7xRSd_iewlSMruH0PcwKXUjQ)

## ORGANIC CHEMISTRY

### 1. Fundamentals of Organic Chemistry

**Stereochemistry:** Conformational analysis of stereocompounds, Effect of conformation on reactivity, Steric-strain, Chirality, R-S nomenclature, Diastereoisomerism in Acyclic and Cyclic systems, E-Z isomerisms, Interconversion of Fischer, Newman and Sawhorse projections, Molecules with more than one chiral center, Threo and erythro isomers, Methods of resolution, Optical activity, Enantiotopic and diastereotopic atoms.

**Pericyclic Reactions:** Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl systems. Classification of pericyclic reactions. Woodward-Hoffmann correlation diagrams, Electrocyclic reactions, Cycloadditions, Sigmatropic rearrangements, Claisen, Cope and Aza-Cope rearrangements, Ene reaction.

**Photochemistry:** Photochemistry of Alkenes, rearrangement of 1,4- and 1,5-dienes, Carbonyl Compounds: Intramolecular reactions of carbonyl compounds, Photo-Fries rearrangement. Barton reaction.

**Aromaticity:** Aromaticity in benzenoid and non-benzenoid compounds, Alternant and non-alternant hydrocarbons, Huckel's rule, Energy level of  $\pi$ -molecular orbitals, Annulenes, Antiaromaticity, Homo- aromaticity.

**Recommended Books:**

Clayden, Greeves, Warren, and Wothers, Organic Chemistry, Oxford University Press (2001).

**NPTEL Link:**

<https://archive.nptel.ac.in/courses/104/106/104106077/>

<https://archive.nptel.ac.in/courses/104/105/104105086/>

<https://archive.nptel.ac.in/courses/104/105/104105038/>

[https://archive.nptel.ac.in/content/storage2/courses/122106029/pdf/1\\_Aromaticity.pdf](https://archive.nptel.ac.in/content/storage2/courses/122106029/pdf/1_Aromaticity.pdf)

## 2. Organic Reaction Mechanism

**Aliphatic Substitution:** Nucleophilic mechanisms ( $S_N1$ ,  $S_N2$ ,  $S_Ni$ ), Neighbouring group, Carbocations, Phenonium ions, Norbornyl system, Nucleophilic substitution-allylic, aliphatic trigonal and a vinylic carbon, Reactivity effects of substrate, Phase transfer catalysis. Ambient nucleophile, Regioselectivity.

**Aromatic Substitution:** Electrophilic mechanism, Orientation and reactivity, Orientation in benzene ring with more than one substituent, Nitration, Halogenation, Sulphonation, Friedal Crafts alkylation and acylation, Sandmeyer, Vilsmeier, Gatterman Koch, Kolbe-Schmidt reactions, Aromatic nucleophilic substitution mechanism ( $S_NAr$ ,  $S_N1$  and Arynes).

**Addition Reaction:** Addition to carbon-carbon multiple bonds, Mechanism of additions involving

electrophiles, nucleophiles and Free radicals, Addition to conjugated systems, Orientation and reactivity,

Hydroboration, Epoxidation, Birch reduction. Addition to carbon-hetero multiple bonds, Addition to carbon oxygen double bond,  $LiAlH_4$ ,  $NaBH_4$ , Aldol, Perkin, Claisen, Benzoin, Benzil-benzilic acid, Mannich, Dieckmann, Michael and Wittig reactions.

**Elimination Reactions:**  $\beta$ -Elimination –  $E2$  and  $E1$ ,  $\alpha$ -elimination.

**Recommended Books:**

Clayden, Greeves, Warren, and Wothers, Organic Chemistry, Oxford University Press (2001).

**NPTEL Link:**

<https://archive.nptel.ac.in/courses/104/101/104101115/>

<https://archive.nptel.ac.in/courses/104/101/104101005/>

## INORGANIC CHEMISTRY

### 1. Fundamentals of Inorganic Chemistry

**Chemistry of some main group elements:** Synthesis, Properties and Structure of halides and oxides, Polymorphism of Carbon, Phosphorus and Sulfur. Synthesis, Properties and Structure of Boranes, Carboranes, Borazines, Silicates Carbides, Silicones, Phosphazenes, Sulphur-Nitrogen, Phosphorous Nitrogen compounds, Peroxo compounds of Boron, Carbon and Sulphur, Oxy-acids of Nitrogen, Phosphorus, Sulphur and Halogens, Interhalogens, Pseudohalides and Noble gas compounds.

**Chemistry of f-block elements:** General discussion on the properties of the f-block elements. Spectral and Magnetic properties, Use of Lanthanide compounds as shift reagents.

**Organometallics:** Organic-transition metal chemistry, Complexes with  $\pi$ -acceptor and  $\sigma$ -donor ligands, 18-electron and 16-electron rules, Isolobal analogy, Structure and Bonding, Transition metal to Carbon bonds in synthesis. Metal cluster compounds, Metal-metal bond, Metal Carbenes, Carbonyl and non carbonyl clusters, Fluxional molecules, Application of organometallic compounds.

**Recommended Books:**

Lee, J.D., Concise Inorganic Chemistry, ELBS, (1996) 5 th ed.

**NPTEL Link:**

<https://archive.nptel.ac.in/courses/104/101/104101090/>

## 2. Coordination Chemistry

**Coordination chemistry:** Bonding in coordination compounds, Crystal field and molecular orbital theory, Splitting of d-orbitals in low-symmetry environments. Molecular orbitals energy level diagrams. Bonding involving  $\pi$ -donor ligands, Jahn-Teller effect, Tanabe-Sugano and Orgel diagrams, Interpretation of electronic spectra Including charge transfer spectra, Spectrochemical and Nephelauxetic series, Magnetism in coordination compounds, Factors affecting the stability of metal complexes.

Reaction Mechanism: Energy profile of a reaction, Reactivity of metal complexes, Inert and labile complexes, Kinetic application of valence bond and crystal field theories, Kinetics of octahedral substitution, Acid and base mediated hydrolysis, Outer sphere type reactions, Cross reactions and Marcus-Hush theory, Inner sphere type reactions, Berry pseudorotation. Substitution reactions in square planar complexes, Trans effect, Mechanism of the substitution reaction.

**Recommended Books:**

Huheey, J.E., Keiter, E. A., and Keiter, R. L., Inorganic Chemistry, Pearson Education (2002) 4 th ed.

**NPTEL Link:**

<https://www.youtube.com/@co-ordinationchemistry1652>

### DEPARTMENT OF ENERGY AND ENVIRONMENT

#### Part A: Research Methodology (50% weightage)

Basic aptitude and reasoning, determinants and matrices, fundamentals of statistics, Measures of central tendencies and dispersion, probability and distributions, hypothesis testing, Z, t-test, two sample test, ANOVA, Tukey test, non-parametric tests, chi-square test, correlation and regression.

Good Laboratory Practices: Safety measures, Handling and storage of chemical and biological material, Aseptic techniques, Laboratory waste disposal, Management of personnel, facilities, buildings and equipment.

Basic Techniques: pH, BOD, COD, Turbidity, F. Coliform, Hardness

Types of research: Basic, applied, qualitative, quantitative, exploratory, descriptive; Sources of information: Journals, books, reports, and online databases; Introduction to Intellectual Property Rights, Types of IP, Patent search, IP management.

#### Part B: Subject-specific content (50% weightage)

Environmental microbiology; Ecology; Environment chemistry; Environment pollution; Environment technologies; Fluid mechanics; Environment quality monitoring; Water and wastewater treatment technology (Physico-chemical and

Biological); Air Quality; Air pollution control technology; Solids and hazardous waste management. Energy resources; Conventional energy technology; Fuels and combustion; Renewable energy Technologies; Life Cycle Assessment (LCA) in energy and environment.

## **SCHOOL OF HUMANITIES & SOCIAL SCIENCES**

### **i. Syllabus for Ph.D. (English Literature)**

**Instruction: There are two sections. Both are compulsory**

#### **Section A: English Literature: Research Methodology**

Documentation Format styles: MLA/APA/Chicago manuals of style (citation practices: in-text citations; bibliography; footnotes and endnotes) Indentation, Margins, Font, Spacing, Heading and Title, Pagination, Abbreviations, Indexing, Glossary and Special Elements such as Title-page, Table of Contents, Headings and Sub-headings, Appendix, Bibliography and Proof Reading. Tone, diction and style, Consistency (spelling, terminology, capitalization for instance), analytical and descriptive writing. Constituents of Research, Research Papers: Abstract writing, structure and main paper. Literature Review. Discourse analysis, textual analysis (i) Novels, short stories, poems, plays, audio-visuals, travel writings, biographies, diaries, long form journalism, popular culture, culinary writing, film writing, sports writing and new genres as primary sources (ii) Print: Books, different types of Journals, National/ International Conference Proceedings among other resources.

#### **Section B: English Literature**

1. Drama
2. Poetry
3. Fiction, short story
4. Non-Fictional Prose
5. Language: Basic concepts, theories and pedagogy. English in Use.
6. English in India: history, evolution and futures
7. Cultural Studies
8. Literary Criticism
9. Literary Theory post World War II

### **ii. Syllabus for Ph.D. (All other specializations except for English Literature)**

**Instruction: Section A is compulsory for all subject areas. The candidates need to select one section from B, C, D, E & F as per their specialization.**

#### **Section A: Research Methodology**

**Introduction to Research:** Meaning of research; Objectives of Research; Motivation for research. Research Process; Criteria of good research. Types of research: Descriptive/Analytical Research; Applied/Fundamental Research; Quantitative/Qualitative Research, Conceptual/Empirical Research.

**Selection the Problem.** Formulation of Research Problem.

**Research Design:** Meaning of Research Design. Features of good research design. Objective(s) and Research Hypothesis. Types of Research Designs: Exploratory;

Descriptive; Diagnostic; Experimental Design. Concepts relating to Research Design: Independent & Dependent variables; Extraneous variables; control variables.

**Review of Literature:** Primary source; Secondary source; Searching e-resources, using search engines; Searching data base. Writing literature review.

**Data Collection:** Sources of Data: Primary and Secondary; Types of Data: Categorical (nominal and ordinal), Numerical (discrete, continuous, ratio and interval).

Methods of Data Collection: Survey, Interviews, Focus Group Discussion, Observation, Records and Experimental Observations; Case study.

**Sampling:** Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non Response. Characteristics of a good sample. Probability and non-probability sampling. Determining size of the sample – Practical considerations in sampling and sample size.

**Data Processing and Analysis:** Statistical Graphics: Histograms, Frequency Polygon, Bar Graphs, Pie Charts, Scatterplots, Boxplots. Descriptive Analysis: Frequency Distributions, Measures of Central Tendency, Measures of Variation/Dispersion, Skewness and Kurtosis; Correlation and Regression.

**Scientific Writing:** Structure and Components of Scientific Reports: Types of Report and significance.

**Research Ethics and Ethical issues related to publishing:** Research Ethics; Committees/Institutional Review Board – Roles and Importance. Reproduction of Published Material; Citation and Acknowledgement. Plagiarism: Concept, types, causes and steps to avoid Plagiarism.

## **Section B: Human Resource Management (HRM)**

**Human resource planning** – concepts, process and techniques, career planning, recruitment and selection, performance appraisal and performance management, compensation management – economic theory of rewards, compensation systems, tools and techniques for designing compensation packages, compensation packages of senior managers, statutory provisions and institutions related to compensation management; motivation, discipline and grievance management, retirement, HR information system, HR accounting, HR audit.

### **Training and Development:**

Learning theories, training – concepts and types, training skills, training needs assessment, action research, designing and delivering training modules, organisational change – process, factors, strategies for managing change, OD interventions and strategies, Human Resource Development – meaning, concepts, quality of work life, HRD climate, interventions, strategies, HRD practices in Indian organisations, coaching and mentoring.

### **Strategic and Global HRM:**

Strategic management and its relevance for HRM, strategic HRM – meaning, concepts, approaches and models, HR strategy formulation, implementation and integration with the business enterprise, evaluation of HR strategy. Global HRM – meaning, concepts, cross-cultural issues, organisational culture and national culture, workforce diversity, HR strategies in MNCs, global sourcing, management and compensation of human resources.

### **Ethics in HRM:**

Understanding Indian and western conceptualisations and theories of ethics, ethical dilemma, ethical climate, stakeholder management, CSR and corporate governance, harassment and discrimination at the workplace, ethical issues in HRM.

## **Section C: Marketing Management**

**Marketing:** Definition, Scope, and Importance, Marketing Philosophies, Importance of marketing in service sector, Characteristics of Services Marketing, CRM & Customer Experience Management

**Marketing Planning & Environment:** Elements of Marketing Mix, Marketing Environment (Micro & Macro)

**Understanding the consumer:** Determinants of consumer behavior, Factors influencing consumer behavior, Consumer Decision-Making Process

**Market Segmentation:** Meaning & Concept, Bases of segmentation, Market Segmentation strategies, Target Marketing, Product Positioning

**Product Management:** Product Life cycle concept, New Product development & strategy, Stages in New Product development, Product decision and strategies, Branding & packaging, Brand Equity

**Pricing, Promotion and Distribution Strategy:** Policies & Practices – Pricing Methods & Price determination Policies. Marketing Communication – The promotion mix, Advertising & Publicity, 5 M's of Advertising Management. Marketing Channels, Retailing, Marketing Communication, Advertising

**Marketing Research:** Introduction, Type of Market Research, Scope, Objectives & Limitations

**Marketing Research Techniques:** Survey Questionnaire design & drafting, Pricing Research, Media Research, Qualitative Research

**Data Analysis:** Use of various statistical tools – Descriptive & Inference Statistics, Statistical Hypothesis Testing, Multivariate Analysis - Discriminant Analysis, Cluster Analysis, Segmenting and Positioning, Factor Analysis

**Emerging trends in Marketing:** Internet Marketing, Sustainable Consumer Behavior, Role of AI, Chatbots, & Automation in Marketing, Neuromarketing, Behavioral Economics & Decision Heuristic

**Business to Business Marketing:** Fundamentals of business markets. Organizational buying process. Business buyer needs. Market and sales potential. Product in business markets. Price in business markets. Place in business markets. Promotion in business markets. Relationship, networks, and customer relationship management. B2B marketing strategies.

## **Section D: Financial Management**

**Introduction to Financial Management** - Goals of the firm - Financial Environments., Simple and Compound Interest Rates, Amortization, Computing more than once a year, Annuity Factor., Bond Valuation, Preferred Stock Valuation, Common Stock Valuation, Concept of Yield and YTM. Defining Risk and Return, Using Probability Distributions to Measure Risk, Attitudes Toward Risk, Risk and Return in a Portfolio Context, Diversification, The Capital Asset Pricing Model (CAPM)

Capital structure and theories, Operating Leverage, Financial Leverage, Total Leverage, and Indifference Analysis in leverage study. Cost of Capital Concept, Computation of Specific Cost of Capital for Equity - Preference – Debt, Weighted Average Cost of Capital – Factors Affecting Cost of Capital 4L. The Capital Budgeting Concept & Process - An Overview, Generating Investment Project Proposals, Estimating Project, After Tax Incremental Operating Cash Flows, Capital Budgeting Techniques, Project Evaluation and Selection - Alternative Methods. Overview, Working Capital Issues, Financing Current Assets (Short Term and Long Term- Mix), Combining Liability Structures and Current Asset Decisions, Estimation of Working Capital. Dividend Policy and theories.

Balance sheet, income statement, cash flow, fund flow financial statement analysis  
Computing and interpreting financial ratios; conducting trend analysis and Du Pont analysis.

**Security Market and Portfolio Management:** The Investment Decision Process; Risk and Return; Introduction to Portfolio Theory; Diversification and Risk; Markowitz and Efficient Frontier; Asset Pricing Models; The Capital Asset Pricing Model (CAPM); Security Market Line; Arbitrage Pricing Theory; • Other Multifactor Models; Various Forms of Efficient Markets; Tests and Implications of Various Efficiency Levels; Fixed Income Securities; Pricing and Valuation; Valuation of Equity;

**Derivatives:** The fundamentals of forward and futures contracts, option contracts and swaps; Credit Derivatives; Value at Risk.

Behavioural Finance: Financial Decision Making, The Expected Utility Rule, Expected Utility Theory: Simple But Untrue?; Noise Traders: Can Investors Get Emotional? Overconfidence and Optimism. Do Investors Trade Too Much? Asset Pricing under Prospect Theory; the Basics of Prospect Theory, Does Prospect Theory Work?; Overreaction and/or reaction; Insider Trading; The Market for Information, Noise and Deception.

## **Section E: Economics**

**Micro-economics** – Demand and Supply Analysis, Theory of Consumer Behaviour, Production & Cost, Market Structures

**Macroeconomics** – National Income Accounting, Classical Theory of Income, Output and Price Determination, Keynesian Aggregate Demand and Aggregate Supply, Consumption function and multiplier, IS-LM Model

**Money and Banking** - Functions of money, Theories of Money Demand, Money Supply, Money multiplier, The Reserve Bank of India and monetary policy, Commercial banks & Credit creation, Instruments of monetary policy-Repo rate, reverse repo rate, cash reserve ratio (CRR), and open market operations (OMO)

**International Economics** – The Balance of Payments Accounts, Trade Theories & Tariffs, The Foreign Exchange Market, Theories of Exchange rate determination, Economic Integration, Regionalism & Multilateralism, Globalization

**Development Economics-** Concepts of development, economic growth models and indicators (GDP, HDI, Gini coefficient), theories of development, environmental impact assessment

**Quantitative Methods-** Probability Theory, Descriptive Statistics, Sampling methods & Sampling Distribution, Statistical Inferences, Hypothesis testing, Linear Regression Models and their properties – BLUE, Time Series Analysis, Input-Output Model, Linear Programming

**Indian Economy-** Pre-independence economy, Post-independence economy, Prime Moving Force: Agriculture vs. Industry, Planned and Mixed Economy, Planning in India, Economic reforms since independence

**Public Finance-** Market Failure, Public Goods, Regulation of Market – Collusion and Consumers' Welfare, Public Revenue, Public expenditure, Public Debt and its management, Public Budget and Budget Multiplier, Fiscal Policy and its implications

## **DEPARTMENT OF MATHEMATICS**

### **Section A (40 Marks)**

Measures of central tendency and dispersion and their properties, skewness and kurtosis, introduction to probability, theorems of total and compound probability, Bayes theorem, random variables and probability distributions, mathematical

expectation, variance, moment generating functions, cumulants and their relation with moments, binomial, Poisson and normal distributions and their properties, correlation and regression, method of least squares, introduction to sampling and sampling distributions like Chi-square,  $t$  and  $F$  distributions, testing of hypothesis, test of significance based on normal,  $t$ , Chi-square and  $F$  distributions.

Vector spaces, Subspaces, Linear dependence, Basis, Dimension, Matrix operations, symmetric, skew-symmetric, Unitary matrices, Hermitian matrices, Rank of a matrix, Determinants and their properties, inverse of a matrix, System of linear equations, Eigenvalues and Eigenvectors, Cayley-Hamilton theorem, diagonalization.

Limit, continuity, differentiation, integration, Maxima-minima of function, partial derivatives, directional derivatives, gradient vectors, gradient, divergence and curl. First order differential equations (separable equations, homogenous, exact, linear, Bernoulli's), second order differential equations (constant coefficient, Cauchy-Eulers).

Algebraic and order properties of  $\mathbb{R}$ , bounded above and below sets, the completeness property of  $\mathbb{R}$ , Archimedean property, definition and types of intervals, neighbourhood of a point in  $\mathbb{R}$ , open and closed sets in  $\mathbb{R}$

Sequences and their properties, bounded sequence, limit superior and limit inferior for bounded sequence, subsequence, limit points, Infinite series and their convergence, alternating series, absolute and conditional convergence. Rolle's Theorem, mean value theorem, Taylor's theorem, Taylor's series, Maclaurin's series, indeterminate forms.

De Moivre's theorem, relation between roots and coefficient of  $n$ th degree equation, solution to cubic and biquadratic equation, transformation of equations.

### **SECTION B (40 Marks)**

Sequences and series of functions, point wise and uniform convergence, Cauchy criterion for uniform convergence, Weierstrass M-test, Abel's and Dirichlet's tests for uniform convergence, uniform convergence and continuity, uniform convergence and Riemann-Stieltjes integration, uniform convergence and differentiation, Weierstrass approximation theorem. Definition, Existence and properties of Riemann integral of a bounded function, Darboux theorem, Condition of integrability, Riemann integrability for continuous functions, bounded functions, monotonic function and functions with finite or infinite number of discontinuities. The integral as the limit of the sums, Properties of Riemann integral, Fundamental theorem of calculus, First Mean value theorems, Change of variables, second mean value theorem, Generalized mean value Theorems.

Algebra of complex numbers, the complex plane, polynomials, power of series, transcendental functions such as exponential, trigonometric and hyperbolic functions. Analytic functions, Cauchy- Riemann equations. Contour integral, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem, Maximum modulus principle.

Measurable sets. Measurable functions. Lebesgue measurability. Non-measurable sets. Integration of Non-negative functions. Riemann and Lebesgue Integrals.

Groups, Subgroups, Normalizer, Centralizer, Normal subgroups, Quotient groups, Homomorphism, Automorphisms of groups and structure of cyclic groups, Permutation groups, Cayley's theorem, Conjugate elements, Class equation, Structure theory of groups, Cauchy theorem, Sylow theory and its applications.

Special kinds of rings, Subrings and ideals, Algebra of ideals, Homomorphism, Quotient rings, Prime and maximal ideals, Quotient rings, Polynomial rings, Integral

domain, Factorization theory in integral domains, Unique factorization domain, Principal ideal domain, Euclidean domain.

Algebra of linear transformations, Algebra of matrices, Matrix representation of linear transformations, Change of basis, Number Theory, arithmetic functions, properties of congruence.

Existence and Uniqueness of solutions of initial value problems for first-order ordinary differential equations, singular solutions of first-order ODEs. Applications of differential equations to vibrations of mass on a spring, Resonance phenomenon. General theory of homogenous and non-homogeneous linear ODEs, variation of parameters, Sturm - Liouville boundary value problem, Green's function. Lagrange and Charpit methods for solving first order PDEs, Cauchy problem for first order PDEs.

## DEPARTMENT OF PHYSICS AND MATERIALS SCIENCE

### Section A

**Numbers and Arithmetic:** Number Systems (Integers, Fractions, Decimals, Real Numbers); LCM and HCF; Percentages, Ratios, and Proportions; Averages and Mixtures

**Algebra:** Basic Algebraic Operations (Equations, Inequalities); Polynomials, Linear Equations, Quadratic Equations; Logarithms and Exponents

**Data Interpretation:** Tables, Charts (Bar graphs, Line graphs, Pie charts), and Graphs; Data Analysis and Interpretation; Measures of Central Tendency (Mean, Median, Mode)

**Mensuration:** Areas and Volumes of Simple Geometrical Shapes (Squares, Rectangles, Triangles, Circles, Cubes, Spheres, Cylinders, Cones)

**Probability and Statistics:** Basic Probability Concepts; Permutations and Combinations; Statistical Distributions (Normal, Binomial – Basic Understanding)

**Problem-Solving:** Dimensional Analysis; Order of Magnitude Estimation; Approximation Techniques; Applying Physics Concepts to Solve Aptitude Problems (e.g., motion, work-energy, etc.).

**Physical world and measurement:** Elementary statics and dynamics; Laws of motion; Work, Energy, and power; Motion of system of particles and rigid body; Gravitation

**Oscillations; Waves; Optics**

**Heat and thermodynamics**

**Electricity and Magnetism:** Electrostatics; Current electricity; Magnetic effects of current and magnetism; Electromagnetic induction and alternating current

### Section B

**Mathematical Methods of Physics:** Vector algebra and vector calculus, Eigenvalues and eigenvectors, Differential equations, Fourier series, Laplace transforms, Elementary probability theory, Binomial, Poisson and normal distribution.

**Classical Mechanics:** Newton's laws, Two body Collisions, Rigid body dynamics, Lagrangian and Hamiltonian formalism and equations of motion, Special theory of relativity, Lorentz transformations, Relativistic kinematics and mass energy equivalence.

**Electromagnetic Theory:** Gauss's law and its applications, Biot-Savart law, Ampere's theorem, Electromagnetic induction, Maxwell's equations, Electromagnetic waves in free space, Dielectrics and conductors.

**Quantum Mechanics:** Wave-particle duality, Schrödinger equation, Particle in a box, Tunneling through a barrier, Heisenberg uncertainty principle, Angular momentum algebra, Addition of angular momenta, Pauli exclusion principle.

**Statistical Physics:** Micro-canonical, canonical and grand-canonical ensembles and partition functions, Classical and quantum statistics, Blackbody radiation and Planck's distribution law.

**Electronics:** Semiconductor devices (diodes, junctions, transistors, field effect devices), Solar cells, Photo-detectors, LEDs, Operational amplifiers, Digital techniques and application, A/D and D/A converters.

**Condensed Matter Physics:** Bravais lattices, Reciprocal lattice, Diffraction, Bonding of solids, Electrical and thermal conductivity, Hall effect, Band theory of solids: metals, insulators and semiconductors, Superconductivity: type-I and type-II superconductors, Defects and dislocations.

**Nuclear and Particle Physics:** Basic nuclear properties: size, shape and charge distribution, spin and parity, Binding energy, Semi-empirical mass formula, Liquid drop model, Shell Model, Nature of the nuclear force, Form of nucleon-nucleon potential, Ideas of alpha, beta and gamma decays and their selection rules, fusion and fission, Nuclear reactions, Classification of fundamental forces, Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness), Quark model, Baryons and Mesons.