8. Ph.D. PROGRAMME (2026-27)

Mode of Program: Regular/Part-time/Executive

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.

Note:

- For executive Ph.D, the candidate must have a minimum of six years professional experience in industry, government organization, public sector undertakings, autonomous bodies, or academic institutions.
- A No Objection Certificate (NOC) from the employer is mandatory in case of Part-time or Executive PhD.

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 in regular/Part-Time PhD program with B.E./B.Tech. or equivalent qualification will be admitted 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 as per needs of the Department/School 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 **800** Ph.D. candidates are working for their Ph.D. degrees in the Institute).

Dept/School	Specilization
BIOTECHNOLOGY	Plant Biotechnology and Bioinformatics (Focused on Legume Genomics and Trait Improvement using Genome Editing
	Protein Engineering
	Plant Molecular Biology/Plant Transformation and Genome Editing
	Oral Microbiota and Chronic Disease
	Immunoinformatics and Immunology
	Epigenomics
CIVIL ENGINEERING	**Structural Health Monitoring (SHM) & Retrofitting of Structures** • 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. • Retrofitting of structures using FRP, Ferro cement and UHP-HFRC, Sandwich panels, and Composite Structures, • High-Temperature Behavior and Fire-Damaged Concrete Systems, Structural Strengthening and Rehabilitation, Advanced and Composite Structural Systems **Structural Engineering** • Passive vibration control, Seismic analysis of structures, Seismic Performance Assessment and Vulnerability Analysis of Structures • Wind, Reliability analysis of structures and High-speed strain loading, Finite Element Modeling of Structures, Reliability based design • Analysis of Composite Structures **Sustainable Construction Materials** • Self-compacting concrete, Ultra-high-performance concrete, Composites in Construction, Sustainable and Waste-Derived Construction Materials, Concrete/Mortar using industrial and agriculture waste • Microbial concrete, Corrosion monitoring and prevention, Sustainable Concrete, Accelerated carbonation curing, Rebar corrosion protection, Corrosion Monitoring,

	Prevention and Rehabilitation • Pavement Materials • Geo-materials. **Water Resource & Environmental Engineering** • Contaminate transport in groundwater Water quality modelling • Fluvial hydraulics • Water resources management • Flood risk analysis • Application of remote sensing and GIS in civil and environmental engineering **Transportation Engineering** • Pavement Maintenance Management Systems for various categories of roads • Computer application for construction industry's challenges • Rheological properties of Paving Bitumen including modified binders • Mechanistic empirical structural design of pavements using various stabilized layers • Development of road safety methodology using sustainable design facilitating NMT and pedestrian traffic • Transportation planning and traffic impact studies **Geotechnical Engineering** • Geotechnical earthquake engineering • Physical modelling in geotechnics, Reinforced earth structures • Ground improvement techniques • Underground structures and Foundation Engineering • Geo-materials and geotextiles
CHEMICAL ENGINEERING	**Transport Phenomena and Thermal Systems** • Numerical heat transfer & fluid flow • Non-Newtonian fluids • Transport in porous media and packed beds • Computational fluid dynamics (CFD) • Industrial-scale residence time distribution (RTD) using radiotracer techniques • Process intensification and heat exchanger design • Heat transfer & hydrodynamics of nanofluids **Thermodynamics and Molecular Modelling**: • Thermodynamic properties and phase transitions of bulk & nanoconfined fluids • Development of equations of state for nanoconfined fluids **Polymer Science and Nanomaterials:** • Nanomaterials • Biopolymers • Biodegradable polymers • Porous organic polymers • Polymer composites and nanocomposites • Graphene-based materials • Shear-Thickening Fluids • Microcellular Polymers • Polymer Coatings and Thin Films • Impact- and Wear-Resistant GFRP

	• Drug Delivery Systems **Sustainable Materials and Energy Systems:** • CO_2 Capture and Utilization, • Biomass torrefaction and biofuel production • Valorization of agricultural and industrial waste • Life-cycle analysis and techno-economic evaluation **Reaction Engineering and Catalysis:** • Heterogeneous reaction & catalysis • Kinetic modeling and reaction pathway optimization • Photocatalysis • Electrocatalytic oxidation • Catalytic conversion of biomass and waste to fuels and chemicals **Environmental and Separation Processes:** • Wastewater treatment • Pollution abatement • Separation process **Computational and Data-Driven Techniques:** • Artificial Intelligence (AI) and Machine Learning in Chemical Engineering • Process modelling and simulation • Optimization
COMPUTER SCIENCE & ENGINEERING	• Artificial Intelligence & Machine Learning • Data Science & Big Data Analytics • Cloud Computing & Distributed Systems • Computer Vision & Image Processing • Cybersecurity and Cryptography • Health Informatics • Human-Computer Interaction (HCI) • Internet of Things (IoT) & Edge Computing • Algorithms and Theoretical Computer Science • Robotics and Autonomous Systems • Natural Language Processing • Computer Networks and Distributed Systems • Quantum Computing • Green Computing • Software Engineering & DevOps
ELECTRONICS & COMMUNICATION ENGINEERING	Fiber Optics Communication, Quantum, Optical Communication
	Antenna and Wireless communication, Antenna Design, Design and Development of Antennas for different applications: Wireless Communication, Biomedical and Food Quality Evaluation, 5G MIMO antennas, UWB antennas, Flexible antennas for Wearable & Implantable applications, Cardiac Pacemaker System and Smart Bandage for Wound Health Monitoring, Microwave absorber and Hyperthermia,
	Wireless Communication, Communication Networks, , Spectrum Sensing, Meta-surfaces for wireless applications, Integrated Sensing and Communication (ISAC), AI/ML and Signal Processing for B5G/6G Communication
	Signal Processing, Signal Processing and Communication, Image Processing, Image & Video Forensics, Biomedical Signal Processing AI-based Image and Signal Processing, Intelligent

	Image Processing, Computer vision, eye tracking, satellite image processing
	MEMS, Semiconductor Materials and Sensors, Multi-Robot Communication and Coordination
	VLSI Design, Analog VLSI design, CNT/GNR based Applications, Digital, Analog & Mixed Signal Circuit Design, VLSI Interconnects, AI applications in biomedical and VLSI industry, Low power system design and test, FPGA-based system Design, ASIC/FPGA-based VLSI Systems, Edge AI hardware and RTL implementation of lightweight security algorithms. Chip Design-Digital, Analog Mixed Signal, AI in chip, Hardware Software Co Design, VLSI for Image Processing, VLSI Circuits and Systems, Device Modelling, Efficient ASIC/FPGA-based VLSI Systems for Signal and Image Processing Applications, and Cryptography Algorithms
	Machine Learning, Deep Learning, Biomedical Images, Deep Learning, Artificial Intelligence, Computer Vision, AI, Medical Technology, Artificial Intelligence in Healthcare Industry, , Using AI/ML for Agri tech/ Healthcare/ Image processing Applications, Natural Language Processing, Artificial Intelligence, Large Language Models, Relay selection problem in D2D Networks and applications of AI/ML in relay selection problem.
	Quantum Computing, Quantum Communication, Network Security, Hardware Security, Neuromorphic Computing,
	Blockchain Technology, Digital Twins, Cloud Computing, Edge & Fog Computing, Privacy Preserving, Pervasive and Ubiquitous Computing, Hardware Security for OoT communication, UAV authentication; Image Security Optical Communication;
ELECTRICAL & INSTRUMENTATION ENGINEERING	• Artificial Intelligence and its applications • AI-based System Level Engineering • Autonomous Vehicles • Biomechanics and Rehabilitation • Biomedical Image Processing • Biomedical Instrumentation • Computer Vision • Computational Biology and Bioinformatics • Control Systems • Cyber-Physical Systems • Cyber and Information Security • Delta operator modelling and control • Digital Twin • Energy Efficiency and Systems • Medical Informatics • IoT and Embedded Systems • Machine/Deep Learning and its applications • Multimedia Processing • Power Electronics and Drives • Power Systems • Process Control • Renewable Energy • Robotics and Automation • Sensor Design and Integration

	• Signal Processing • Smart & Micro-grid, Electric Vehicles • System Identification
MECHANICAL ENGINEERING	• Advanced Manufacturing, Advanced Manufacturing Processes • Synthesis of Polymer Nanocomposites for improved mechanical properties and wear characteristics • Industrial Engineering • Advanced Machining Processes • Composites, Polymer Nano composites, Design of Composite Materials • Thermal Spray Coatings • Biomedical, Additive Manufacturing, Advanced Machining • Welding • Physical-mechanical metallurgy and high speed imaging technique • Electron Beam Welding • 3D Printing • Active & Passive Health Monitoring • Mechanics of Composite Materials, FEM • Nonlinear Dynamics, Vibration Control, MEMS, Oprimization of Micro structures, Structural health Monitoring, 3D Printing: Co-printing conductive and structural materials, Influence of AM-induced anisotropy on modal behaviour. • Tribology, Composites & Coatings • General Noise and Vibration • Acoustics and Vibrations • Hybrid Vehicles, System Dynamics and Control • Autonomous Underwater and Surface Robots, Adaptive guidance controls • Micro-robotics, Mobile Robotics • Mechanical Vibrations, Condition monitoring, AI • Thermal Engineering • Powder and Bulk Solids • Solar Energy, Fluid Flow & Heat Transfer • Heat Transfer • Green hydrogen generation, Hydrogen storage, PEM Fuel Cell and applications • Thermo-fluids, CFD, RAC, Nano and micro-Powders flowability • Particle Engineering, Polymer Nanocomposites for improved mechanical properties and wear characteristics • Fluid & Thermal, Hydrogen storage systems, AI applications in CFD • Computational Fluid Dynamics, Electronics cooling, Li ion battery cooling, Hydrogen storage modelling, Thermal spray coating simulation, droplet impact, Metal additive manufacturing simulation.
CHEMISTRY & BIOCHEMISTRY	**A. Biochemistry** 1. Biophysical Chemistry 2. Cancer Biology 3. Diabetes

	4. Drug Development 5. Protein Misfolding **B. Catalysis** 1. Biocatalysis 2. Electrocatalysis 3. Nano catalysis 4. Photocatalysis **C. Computational Chemistry** 1. Computational aided reaction mechanism 2. Computational Catalysis 3. Computer aided drug design **D. Materials** 1. Nanomaterials 2. Organic Materials 3. Sustainable Materials 4. 2D functional Materials 5. Quantum Materials **E. Sensors** 1. Electrochemical Sensors 2. Nano Sensors 3. Organic Sensors **F. Synthesis** 1. Bioorganic Chemistry 2. Biotransformation 3. Medicinal Chemistry 4. Organic Chemistry 5. Supramolecular Chemistry
ENERGY & ENVIRONMENT	Water and Wastewater treatment Technologies, Environmental Nanotechnology, Waste Management, Sustainability, Life Cycle Analysis
HUMANITIES AND SOCIAL SCIENCES	• Human Resource Management • Economics and Finance • Finance • Library and Information Science
MATHEMATICS	• Algebra • Optimization, Operations Research: Data Analysis and Prediction • Approximation Theory, Analysis • Nonlinear Analysis, Fixed Point Theory • Differential Equations, Fluid Dynamics • Quantum Computation • Physics informed neural networks, Artificial Intelligence • Applied Mathematics, Wave propagation in elastic solids • Numerical Analysis, Partial Differential Equations • Computational Fluid Dynamics (CFD), Traffic flow Modelling and Simulation • Analysis and Numerics of Integro Differential Equations,

	Particle Population Dynamics • Numerical Analysis, Numerical Linear Algebra • Probability and Statistics • Number Theory • Ordinary Differential Equation and their Applications, Mathematical Modleing in Epidemiology • Differential Equations: Wave propagation in Advanced Materials • Astrophysics, Fluid dynamics • Statistical Inference, Bayesian estimation and prediction
PHYSICS & MATERIALS SCIENCE	Condensed Matter Physics-Experimental, Solid-State Physics, Materials Science, Quantum Materials, Condensed Matter Theory, Computational Soft Condensed Matter, Theoretical Nuclear Physics, Particle Physics, Environmental Radioactivity-Experimental, Non-Linear Dynamics, Photonics, Statistics

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, 2026

Date for issuing the admit card through registered email ID : July 17, 2026

Entrance Test to be conducted by TIET : July 22, 2026

Display of Result of Entrance Test : July 24, 2026

Dates of interview : July 27, 2026 onwards

Entrance Test for Ph.D. programme shall be conducted ONLINE 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 six 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
e) For Executive program:
    - Candidate with a postgraduate (PG) degree are required to complete 12-16 credits as per UGC norms. Candidate holding a UG degree with 75% or higher will be required to complete 12 additional master level credits in addition to 12-16 credits of UGC-mandated coursework.
    - Those with an four year undergraduate percentage between 60% and 75% are required to enroll in the accelerated master's program (of 36-40 credits) and can thereafter pursue Ph.D.

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.

iv. The Summary of course work applicable to different Ph.D modes is given below

Admission Type	**Admission Criteria**	**Course-Work Credit**
Regular/ Part-Time	Master Degree	36- Credits
Executive	Master Degree	12-16 Credits
Regular/ Part-Time	UG Degree >= 75%	36 Credits+ 8 Master level Courses
Executive	UG Degree >= 75%	(12-16) + 12 Master level Credits
Executive	UG Degree < 75% but >= 60%	(12-16) + Accelerated master's program (of 36-40 credits)

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:

a. Candidate senior in age shall rank higher in order of merit.
b. 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.

c. 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, 2026****, 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, compliment 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

Section A-Research methodology (Compulsory, <u>50% weightage</u>)

- 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

Section B-Subject-specific (50% weightage)

This section has two subsections. Candidates can choose any one subsection from the following two subsections as per their area of interest or Master's degree specialization.

1. *Chemical Engineering* **OR**
2. *Chemical & Allied Discipline* (Chemistry/Chemical Technology/Biotechnology/Energy & Environment/Mechanical Engineering)

1. *Chemical Engineering*

- 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

OR

2. *Chemical & Allied Discipline*

- Atomic structure, chemical bonding and molecular structure, mole concept, concentration terms, and empirical formulas, chemical and ionic equilibria,

chemical kinetics, solutions, surface chemistry, states of matter, thermodynamics, and adsorption.
- Particle size and shape, particle size distribution, size reduction and classification of solid particles; free and hindered settling; centrifuges and cyclones; thickening and classification, filtration, agitation and mixing; conveying of solids, etc.
- Chemical process industries.
- Biochemistry and biomaterials, cell and molecular biology, environmental biotechnology, industrial biotechnology and bioprocess engineering, molecular and analytical techniques.
- Identification, quantification, and analysis of water/wastewater, different treatment methods including physico-chemical and biochemical techniques, disinfection, classification of air pollutants, nature and characteristics of gaseous and particulate pollutants, air pollution control equipment, treatment and disposal of solid wastes; Solar Energy, Biomass & Bioenergy, Wind Energy, Hydropower, Geothermal Energy, Tidal Energy, Hydrogen Energy, Electrical Energy using nuclear power.
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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:

Basic Programming Concepts:- Iterative programming (for and while loop constructs), conditional executions, Array, functions, pointers, recursion, file handling, procedural and object-oriented programming concepts.

Data Structures: - Stacks, queues, linked lists, trees, binary search trees, binary heaps, graphs.

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

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

Theory of Computation:- Regular expressions and finite automata. Context-free grammars and push-down automata. Regular and context-free languages, pumping lemma. Turing machines and undecidability.

Compiler Design:- Lexical analysis, parsing, syntax-directed translation. Runtime environments. Intermediate code generation. Local optimization, Data flow analyses: constant propagation, liveness analysis, common sub expression elimination.

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

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

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

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 & INSTRUMENTATION ENGINEERING DEPARTMENT

SPECIALIZATION: 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; basis 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.

SPECIALIZATION: 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.

SPECIALIZATION: BIOMEDICAL ENGINEERING

Linear Algebra: Matrix algebra, systems of linear equations, eigenvalues and eigenvectors. Calculus: Mean value theorems, theorems of integral calculus, partial derivatives, maxima and minima, multiple integrals, Fourier series, vector identities, line, surface and volume integrals, Stokes, Gauss and Green's theorems.

Differential equations: First order linear and nonlinear differential equations, higher order

linear differential equations with constant coefficients, Cauchy's and Euler's equations, initial and boundary value problems, and solution of partial differential equations.

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

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

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

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

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

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

Human Anatomy and Physiology: Basics of cell, types of tissues and organ systems; Homeostasis; Basics of organ systems - musculoskeletal, respiratory, circulatory, excretory, endocrine, nervous, gastro-intestinal and reproductive.
Medical Imaging Systems: Basic physics, Instrumentation and image formation techniques in medical imaging modalities such as X-Ray, Computed Tomography, Single Photon Emission Computed Tomography, Positron Emission Tomography, Magnetic Resonance Imaging, Ultrasound.

Biomechanics: Kinematics of muscles and joints - free-body diagrams and equilibrium, forces and stresses in joints, biomechanical analysis of joints, Gait analysis; Hard Tissues - Definition of Stress and Strain, Deformation Mechanics, structure and mechanical properties of bone - cortical and cancellous bones; Soft Tissues - Structure, functions, material properties, visco elastic properties, Maxwell & Voight models; Biofluid mechanics - Flow properties of blood in the intact human cardiovascular system.
Biomaterials: Basic properties of biomaterials - Metallic, Ceramic, Polymeric and Composite; Fundamental characteristics of implants - biocompatibility, bioactivity, biodegradability; Basics of drug delivery; Basics of tissue engineering. Biomaterial characterization techniques - Rheology, Atomic Force Microscopy, Electron Microscopy, Transmission Electron Microscopy Fourier Transform Infrared Spectroscopy.

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, 1H NMR, 13C 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=MGmL84HdBcbc17qt

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=PLOzRYVm0a65eCqECeSQJwmKX6D4zibX84

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=PLII3zV64b7xRSd_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, Cycloaddditions, 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 -molecular orbitals, Annulenes, Antiaromaticity, Homo- aromaticity.

Recommended Books:

Clayden, Greeves, Narren, 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

2. Organic Reaction Mechanism

Aliphatic Substitution: Nucleophilic mechanisms (SN1, SN2, SNi), 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, Sandmayer, Vilsmeier, Gatterman Koch, Kolbe-Schmidt reactions,Aromatic nucleophilic substitution mechanism (SNAr, SN1 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: β-Elimination – E2 and E1, a-elimination.

Recommended Books:

Clayden, Greeves, Narren, 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 π-acceptor and σ-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 orgnaometallic 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 π-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.

DEPARTMENT OF HUMANITIES & SOCIAL SCIENCES

Instruction: Section A is compulsory for all subject areas. For management section B is also compulsory. The candidates need to select one section from C, D, E, F & G 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 nonprobability 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: General Management

Evolution of Management Thoughts: Classical management Era (1880-1930), Neoclassical Management Era (1930-1950), Modern Management era (1950-onwards). Contribution of Management Thinkers: Taylor, Fayol, Elton Mayo etc.

Functions of Management: Planning, Organizing, Staffing, Directing, Controlling.

Organizational Design: Classical, Neoclassical and Contingency approaches to organizational design; Organizational theory and design, Organizational structure (Simple Structure, Functional Structure, Divisional Structure, Matrix Structure)

Section C: 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, crosscultural 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 D: 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 E: 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 F: 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

Section G: Library and Information Science
Library and Information Science - Information Science and Information Society; Five Laws of Library Science; Library Movement in India; Library Acts; National and Internal Associations: Source of Information; Evaluation of Information; Information Literacy and Model; Different Kinds of Databases; User Centric Library Services; Classification and Cataloguing System; Citation and Indexing System; Knowledge Management; Management Principles; Total Quality Management; Collection Development Principles; Leadership Principles; Library Automation; Computer Application in Library and Automation; Metadata Standards; Intellectual Property Rights; Creative Common; Open Access; Institutional Repositories; Ethics; Standards; Research Methods focussed on Library and Information Science; Recent Advancement in LIS in India and Globally with special reference to Artificial Intelligence.

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 R, bounded above and below sets, the completeness property of R, Archimedean property, definition and types of intervals, neighbourhood of a point in R, open and closed sets in 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 nth 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 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.