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
Centre of Excellence in Data Science and AI*	Data Science & AI

*in collaboration with The University of Queensland (UQ), Australia (TIET – UQ Joint PhD programme)

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 OFFLINE by respective departments/schools and the candidates will be informed accordingly.

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

8.8 DURATION

The student shall submit his/her thesis to the Registrar within 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 a 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 OFFLINE 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.

8.13 PH.D. ENTRANCE EXAMINATION SYLLABUS

1 **Part – A - Research Methodology (Common for All Departments)**

Note: *The test will consist of 5 sections, each containing 10 questions.*

Objective: To identify candidates who possess the necessary aptitude, analytical ability, communication skills, and research orientation required for pursuing PhD-level research successfully.

Unit – 1: Reading Comprehension & Communication Skills

- Reading passages (short & long)
- Main idea, inference, tone, purpose
- Vocabulary (synonyms, antonyms, context-based meaning)
- Basic grammar (tenses, articles, prepositions)
- Sentence correction
- Academic writing basics (clarity, formal tone)

Unit – 2: Logical Reasoning

- Analogies
- Classification (odd one out)
- Coding–decoding
- Blood relations
- Direction sense
- Syllogism
- Statement–conclusion / assumption
- Number & alphabet series

Unit – 3: Analytical Reasoning & Quantitative Aptitude

- Data interpretation (tables, graphs, pie charts)
- Percentages, ratio, averages
- Profit & loss, simple interest
- Number patterns & sequences
- Basic puzzles (seating, arrangement)
- Problem-solving & decision-making

Unit – 4: Research Methodology & ICT

- Basics of research (types, process, problem, hypothesis)
- Research design (qualitative & quantitative)
- Sampling & data collection methods
- Basic statistics (mean, median, correlation)
- Research ethics & plagiarism
- Report writing & referencing
- ICT tools: MS Office, internet, e-resources (Google Scholar, Shodhganga)

Unit – 5: General Awareness

- Current affairs (national & international)

- Indian education system & policies
- Science & technology basics
- Government schemes
- Important organizations (UGC, AICTE, ISRO, WHO, etc.)
- Static GK (capital, currency, national symbols)

2 **Part – B – Subject Specific**

DEPARTMENT OF BIOTECHNOLOGY

Cell wall and cell membrane, Structural organization and function of intracellular organelles, Organization of genes and chromosomes, Operon, unique and repetitive DNA, cell cycle regulation, Mitosis and meiosis, Microbial Growth kinetics.

DNA replication, repair and recombination, RNA synthesis and regulation, Protein synthesis, protein transport and degradation, Genetic regulation of transcription and translation, gene silencing, epigenetic regulation.

Cell signaling, plant two-component systems, light-signaling in plants, bacterial chemotaxis and quorum sensing, extracellular matrix, integrins, neurotransmission and its regulation, haematopoiesis, Innate and adaptive immune system - Cellular and molecular basis, Host pathogen interaction, Cancer genetics.

Photosynthesis, Respiration and photorespiration, Nitrogen metabolism, biological nitrogen fixation, Plant hormones and physiology, Plant secondary metabolites.

Principles of Mendelian inheritance, Chromosomal and extrachromosomal inheritance, Genes and mutations, Genetic analysis, gene transfer in bacteria: transformation, conjugation, transduction, Human and quantitative genetics, Population genetics and Hardy-Weinberg equilibrium, chromosomal basis of genetic diseases

Bioinformatics- databases, scoring matrix, sequence alignments, multiple sequence alignments (MSA), phylogenetic analysis, Gene annotation, Molecular Modelling, 3-D structure visualization, Secondary and tertiary structure prediction, homology/comparative modelling, Drug design, Systems Biology - health and drug discovery.

Material and energy balance, transport phenomena, heat and mass transfer, mass transfer equipment's, Thermodynamics in Biological Systems, biological clocks. Bioprocess Engineering - bioreactors and substrate utilization in batch, fed-batch and continuous systems, mass transfer of oxygen, aeration and agitation, fluid rheology, Fermentation technology- antibiotics, organic acids, alcohol, bioplastics, vitamins, enzymes.

Enzymes, enzyme engineering, protein engineering, biocatalysis, immobilization of enzymes and whole cells, metabolic engineering and synthetic Biology.

Biomass separation and disruption methods, Precipitation by salts, solvents, Membrane based purification, Adsorption and chromatography, Extraction (solvent, aqueous two-phase, super critical), Drying.

Bioprocess Plant Design - Process flow sheet, Scale-up and scale-down issues, selection and specifications of bioprocess equipment,

Molecular cloning, expression of recombinant proteins, In vitro mutagenesis and deletion techniques, gene knock out and genome editing techniques. Protein & DNA sequencing methods

Vaccines (Live, killed, attenuated, subunit, and recombinant nucleic acid vaccines) and diagnostics, adjuvants, cell therapy, stem cell therapy, immunotherapy, r-DNA based therapy, antibody engineering, phage display libraries, tissue engineering.

Transgenic animals, animal breeding, germplasm conservation, molecular diagnosis of pathogens, cell cloning and selection, cell and tissue culture methods in biotechnological applications. Transgenic plants, diagnosis and strain identification, agricultural applications, plant breeding methods, gene introgression and pyramiding.

Marine organisms and their biology, behaviour and applications, marine microbes, secondary metabolites of Marine organisms and microorganisms, fouling and corrosion and biofilms, Environmental Biotechnology, Isolation of biomacromolecules, Bioanalytical and Biophysical methods

Genomics, Transcriptomics, Proteomics and Metabolomics of prokaryotic and eukaryotic organism's Comparative genomics and transcriptomics, DNA fingerprinting and DNA Barcoding. Radioisotopes and Radiolabelling techniques in biology.

Histochemical & Immunotechniques viz. ELISA, Immunoprecipitation, Flow cytometry, Immunofluorescence. Light Microscopy and advanced microscopic techniques, sample preparation methods of microscopic techniques.

Evolution of Life and Life Forms, Ecology, Intellectual Property rights, Biosafety and Statistical methods in biology

CHEMICAL ENGINEERING DEPARTMENT

Laws of Thermodynamics and their Applications; Stoichiometry; Material and Energy Balances; Fundamentals of Fluid Mechanics Including Fluid Properties, Pipe Flow, Flow Measurement, and Pumps; Heat Transfer Principles including Conduction, Convection, Radiation, and Heat Exchangers; Mass Transfer Operations such as Diffusion, Absorption, Adsorption, Distillation, and Extraction; Reaction Kinetics of Homogeneous and Heterogeneous Systems; Overview of Chemical Process Industries including Fertilizers, Nitrogen and Phosphorus Industries, Chlor-Alkali, Edible and Essential Oils, Soaps, Glycerin, and Detergents; Mechanical Operations Including Size Reduction, Particle Classification, Settling, and Filtration; Wastewater Analysis and Treatment Methods; Renewable and Non-Conventional Energy Resources.

CIVIL ENGINEERING DEPARTMENT

Surveying

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

Structural Engineering

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

Structural Analysis: Analysis of statically determinate trusses, arches, beams, cables, displacements in statically determinate structures (moment area theorem, unit load method) and analysis of statically indeterminate structures by force method (Method of Consistent Deformations), analysis by displacement methods (slope deflection and moment distribution methods),

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. Fundamentals of earthquake, IS1893: 2016

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

Geotechnical Engineering

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. Stability of retaining walls. Stability of slopes - infinite slopes, finite slopes, method of slices, total stress analysis. 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.

Water Resources & Environmental Engineering

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

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,

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

Environmental Engineering

Basics of water quality standards _ Physical, chemical and biological parameters; Water quality index; Water requirement; Water distribution system; Design aspects of water treatment plant and Sewerage system.; Sludge disposal; Reuse of treated sewage for different applications. Air pollution and Control.

Transportation Engineering

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

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

Networks, Signals & Systems: Network theorems (Superposition, Thevenin, Norton, Maximum Power Transfer), nodal/mesh analysis, network graphs. Transforms: Laplace, Fourier, Z-transform; time & frequency response. Two-port networks (Z, Y,

ABCD, h), transfer functions, poles & zeros, Bode plots. Signal representation, sampling theorem, continuous & discrete signals, DFT/FFT. Basics of DSP, IIR & FIR digital filters.

Electronic Devices: Semiconductor fundamentals: energy bands, Fermi level, density of states. PN junction, diode models, Zener & tunnel diodes, breakdown mechanisms. BJT, JFET, MOSFET characteristics. Metal-semiconductor junctions (Ohmic, Schottky). Optoelectronic devices: LED, LCD, flexible displays. CMOS technology, short-channel effects, fabrication & scaling.

Analog Circuits: Rectifiers, regulated power supplies, transistor biasing & stability. Amplifiers, feedback concepts, oscillators (Hartley, Colpitts, Phase Shift). Op-amps: characteristics, applications (comparators, Schmitt trigger, instrumentation amplifiers). Wave shaping, PLL, active filters, multivibrators, V/F and F/V converters.

Digital Circuits & Embedded Systems: Logic gates, Boolean algebra, minimization. Combinational & sequential circuits (flip-flops, counters, shift registers). Memories (ROM, SRAM, DRAM), ADC/DAC. PLD, CPLD, FPGA, HDL (VHDL/Verilog). Processor basics: RISC, ALU, datapath, pipelining (ARM). Fundamentals of IoT and communication systems.

Control Systems: System components, feedback, transfer functions, block diagrams, signal flow graphs. Transient & steady-state analysis of LTI systems. Stability: Routh-Hurwitz, Nyquist. Frequency response, Bode & root locus plots. Compensation techniques (lag, lead, lag-lead). State-space analysis.

Communications: Analog modulation: AM, FM, PM; super heterodyne receiver. Noise analysis, information theory basics, error control. Digital modulation: PCM, ASK, FSK, PSK, QPSK, QAM. Multiplexing & multiple access techniques. Mobile, satellite & data communication basics. Optical communication: sources, detectors, fibers, WDM. Random processes: autocorrelation, PSD, noise filtering.

Electromagnetics: Electrostatics, magnetostatics, Maxwell's equations, wave propagation. Reflection, refraction, polarization, interference, diffraction. Transmission lines & waveguides. Antennas: dipole, radiation patterns, gain, Friis equation. Microwave devices: Klystron, Magnetron, TWT, Gunn & IMPATT diodes.

AI & Machine Learning: Fundamentals of AI, ML, and deep learning. Computer vision, NLP, large language models. Applications in healthcare, agriculture, and image processing. AI/ML in communication systems (e.g., D2D networks).

ELECTRICAL & INSTRUMENTATION ENGINEERING DEPARTMENT

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.

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: 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.

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

MECHANICAL ENGINEERING DEPARTMENT

Applied Mechanics and Design

Engineering Mechanics: Free-body diagrams and equilibrium; friction and its applications; trusses; kinematics and dynamics of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations; Lagrange's equation.

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

Theory of Machines: Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of linkages; cams; gears and gear trains; flywheels and governors; balancing of rotating masses.
Vibrations: Free and forced vibration of single degree of freedom systems, effect of damping; vibration isolation; resonance.
Machine Design: Design for static and dynamic loading; failure theories; fatigue strength and the S-N diagram; principles of the design of machine elements, brakes and clutches.

Fluid Mechanics and Thermal Sciences

Fluid Mechanics: Fluid properties; fluid statics, forces on submerged bodies, stability of floating bodies; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; dimensional analysis; viscous flow of incompressible fluids, boundary layer, elementary turbulent flow, flow through pipes, head losses in pipes; basics of compressible fluid flow.
Heat Transfer: Modes of heat transfer; one-dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system, thermal boundary layer; heat exchanger performance, LMTD and NTU methods; radiative heat transfer, Stefan-Boltzmann law, Wien's displacement law, black and grey surfaces, view factors.
Thermodynamics: Thermodynamic systems and processes; properties of pure substances, behaviour of ideal and real gases; zeroth and first laws of thermodynamics, calculation of work and heat in various processes; second law of thermodynamics; thermodynamic property charts and tables, availability and irreversibility; thermodynamic relations.
Applications: Power Engineering: Air and gas compressors; vapour and gas power cycles, I.C. Engines: Air-standard Otto, Diesel and dual cycles.
Refrigeration and air-conditioning: Vapour and gas refrigeration and heat pump cycles; properties of moist air, psychrometric chart, basic psychrometric processes. Turbomachinery: Impulse and reaction principles, velocity diagrams.

Materials, Manufacturing and Industrial Engineering

Engineering Materials: Structure and properties of engineering materials, phase diagrams, heat Treatment, stress-strain diagrams for engineering materials. Casting, Forming and Joining Processes: Different types of castings; solidification and cooling; Plastic deformation and yield criteria; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering.
Machining and Machine Tool Operations: Mechanics of machining; basic machine tools; single point cutting tools, tool geometry and materials, tool life and wear; economics of machining; principles of non-traditional machining processes; NC/CNC machines and CNC programming.
Metrology and Inspection: Limits, fits and tolerances; linear and angular measurements; comparators; finish measurement.
Computer Integrated Manufacturing: Basic concepts of CAD/CAM and their integration tools; additive manufacturing.

DEPARTMENT OF CHEMISTRY AND BIO-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

4. 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

5. 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/

6. 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/

7. 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

8. Water, pH, and Buffers

Properties of Water: Explains water's unique properties, including polarity, hydrogen bonding, and its role as a solvent in biological systems.

Osmosis and Diffusion: Covers diffusion and osmosis, the processes by which molecules move across membranes, and their relevance in biological systems.

pH, pKa, and Biological Buffers: Discusses pH, pKa, acid-base balance, and the function of biological buffers like phosphate and bicarbonate in maintaining cellular stability.

Recommended Book:

Moran, Horton, Scrimgeour, Principles of Biochemistry (2011), Pearson Education India, 5th Edition. Upadhyay, Nath & Upadhyay., Biophysical Chemistry (2020), Himalaya Publishing House Pvt. Ltd. Nelson & Cox., Lehninger Principles of Biochemistry, (2017) WH Freeman, 7th Edition

9. Proteins, Carbohydrates and Nucleic Acids

Protein Structure and Function: Study of amino acids, peptide bonds, and levels of protein structure (primary to quaternary). Explore protein domains, motifs, and their biological roles.

Enzymes and Reaction Kinetics: Enzyme classification, mechanism of action, Michaelis-Menten kinetics, enzyme inhibition, and allosteric regulation. Techniques: spectrophotometry, enzyme assays, and graphical kinetic analysis.

Photosynthesis: Covers the process of photosynthesis, focusing on light-dependent reactions, Calvin cycle, and the production of glucose as energy storage.

Carbohydrate Structure and Function: Study of monosaccharides, disaccharides, and polysaccharides, including glycosidic bonds and biological roles like energy storage and signalling.

Structure and Types of Nucleic Acids: Study of DNA and RNA structure, nucleotide components, base pairing, and differences between DNA and RNA.

Recommended Book:

Voet, Voet and Pratt, Fundamentals of Biochemistry (2016), John Wiley & Sons Inc, 5th Edition. Nelson & Cox., Lehninger's Principles of Biochemistry, (2017) WH Freeman, 7th Edition

DEPARTMENT OF ENERGY AND ENVIRONMENT

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

Fundamentals of Management

Concept, Nature, Process, and Significance of Management, Evolution of Management Thought: Classical, Neo-classical, and Modern Approaches, Management Functions: Planning, Organising, Staffing, Directing, and Controlling, Decision Making: Process, Types, and Models, Social Responsibility and Ethics in Management

Economics

Microeconomics: Law of Demand, Elasticity, Consumer Behaviour, Market Structures, Macroeconomics: National Income Accounting, Inflation, Monetary and Fiscal Policy, Managerial Economics: Business cycles and decision-making under uncertainty

Human Resource Management

HRM Foundations: Job Analysis, Recruitment, Selection, and Induction, Training and Development: Methods and Evaluation, Performance Appraisal and Merit Rating, Compensation Management and Employee Welfare, Organisational Behaviour: Personality, Perception, Motivation, and Leadership

Finance & Commerce

Accounting Principles: GAAP, Financial Statements, Ratio Analysis, Financial Management: Time Value of Money, Capital Budgeting, Cost of Capital, Working Capital Management and Dividend Policy, Business Environment and International Business Foundations

Marketing Management

Marketing Mix (4Ps & 7Ps), Market Segmentation, Targeting, and Positioning (STP), Consumer Buying Behaviour and Product Life Cycle, Branding, Packaging, and Pricing Strategies, Digital Marketing and Service Marketing Basics

DEPARTMENT OF MATHEMATICS

Real Analysis: 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 (without proof). 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.

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

Complex Analysis: 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.

Algebra and Number Theory: 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.

Ordinary and Partial Differential Equations: 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.

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DEPARTMENT OF PHYSICS AND MATERIALS SCIENCE

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.

CENTRE OF EXCELLENCE IN DATA SCIENCE AND AI

Basic Programming Concepts:- Iterative programming (for and while loop constructs), conditional executions, Array, functions, pointers, recursion, flle 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.

Data Science & AI:- Fundamentals of Data Science, Machine Learning, Deep Learning, Artificial Intelligence Fundamentals, Generative AI and Large Language Models, Data analytics and Big Data, AI applications.