Admission Brochure

Joint M.Tech./MCP-Ph.D.Programme

2024 - 25

Indian Institute of Technology Kharagpur

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Contents

Disclaimer: JMP 2024-25 **i**

Contents **iii**

1 The Institute **1**
1.1 About The Institute . . . 1
1.2 Academc Structure of the Institute . . . 1
1.3 Postgraduate Degrees Conferred in the 2022 . . . 2
1.4 Central Library . . . 2
1.5 Center for Computational and Data Science (CCDS) . . . 2
1.6 Technology Students Gymkhana . . . 3
1.7 Accommodation and Amenities . . . 3
1.8 Recreational/Extra Curricular Activities . . . 3
1.9 Health Care . . . 4
1.10 Counselling Center . . . 4
1.11 Sponsord Research and Industrial Consultancy (SRIC) . . . 4
1.12 Joint M.Tech./MCP/M.Arch. Programme of IIT Kharagpur . . . 5

2 Information About Various Departments/Schools/Centres **7**
2.1 DEPARTMENT OF AEROSPACE ENGINEERING . . . 7
2.2 DEPARTMENT OF AGRICULTURAL AND FOOD ENGINEERING . . . 8
2.3 DEPARTMENT OF ARCHITECTURE AND REGIONAL PLANNING . . . 10
2.4 DEPARTMENT OF BIOSCIENCE AND BIOTECHNOLOGY . . . 12
2.5 DEPARTMENT OF CHEMICAL ENGINEERING . . . 13
2.6 DEPARTMENT OF CIVIL ENGINEERING . . . 14
2.7 DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING . . . 16
2.8 DEPARTMENT OF ELECTRICAL ENGINEERING . . . 17
2.9 DEPARTMENT OF ELECTRONICS & ELECTRICAL COMMUNICATION ENGINEERING . . . 19
2.10 DEPARTMENT OF GEOLOGY AND GEOPHYSICS . . . 21
2.11 DEPARTMENT OF INDUSTRIAL & SYSTEMS ENGINEERING . . . 22
2.12 DEPARTMENT OF MATHEMATICS . . . 24
2.13 DEPARTMENT OF MECHANICAL ENGINEERING . . . 25
2.14 DEPARTMENT OF METALLURGICAL & MATERIALS ENGINEERING . . . 26
2.15 DEPARTMENT OF MINING ENGINEERING . . . 29
2.16 DEPARTMENT OF OCEAN ENGINEERING & NAVAL ARCHITECTURE . . . 31
2.17 DEPARTMENT OF PHYSICS . . . 33
2.18 ADVANCED TECHNOLOGY DEVELOPMENT CENTRE . . . 34
2.19 CENTRE FOR OCEANS, RIVERS, ATMOSPHERE & LAND SCIENCES . . . 36
2.20 CRYOGENIC ENGINEERING CENTRE . . . 38
2.21 MATERIALS SCIENCE CENTRE . . . 40
2.22 SUBIR CHOWDHURY SCHOOL OF QUALITY & RELIABILITY . . . 42
2.23 RUBBER TECHNOLOGY CENTRE . . . 44
2.24 Centre of Excellence in Artificial Intelligence . . . 44
2.25 Centre of Excellence in Safety Engineering and Analytics . . . 45

2.26 G. S. SANYAL SCHOOL OF TELECOMMUNICATIONS 47
2.27 RANBIR & CHITRA GUPTA SCHOOL OF INFRASTRUCTURE DESIGN & MANAGEMENT 48
2.28 SCHOOL OF ENERGY SCIENCE AND ENGINEERING 49
2.29 SCHOOL OF MEDICAL SCIENCE AND TECHNOLOGY 51
2.30 SCHOOL OF WATER RESOURCES 53
2.31 Rajendra Mishra School of Engineering Entrepreneurship 60

3 General Information for Applicants 63
3.1 Eligibility and Assistantship for Regular Applicants (through GATE) 63
3.2 Application Fee 64
3.3 Choice of Courses 64
3.4 How to Apply (Regular Applicants through GATE Score) 65
3.5 POST ADMISSION INFORMATION 65
3.6 Important Dates 67

4 Appendix: List of Tables for Reference 69

One

The Institute

1.1 About The Institute

Indian Institutes of Technology (IITs) were established to cater to the country's growing need for trained manpower with higher learning in science and technology. The Indian Institute of Technology Kharagpur, first of the chain of IITs, was established in 1950 in the idyllic and sylvan settings at Hijli in West Bengal. From a modest start in the dilapidated Hijli jail building, IIT Kharagpur has grown into one of the largest and most well-known technological institutes of the country. The handsome main building with its majestic tower was inaugurated in 1956. Pandit Jawaharlal Nehru in the first convocation in the same year said "here in the place of that Hijli detention camp stands this fine monument of India, representing India's urges, India's future in the making. This picture seems to me symbolic of changes that are coming to India".

Today, IIT Kharagpur has come a long way to its present position of pre-eminence with 19 academic departments, 17 multidisciplinary centres, a School of Management, a School of Telecommunications, a School of Medical Science and Technology and a School of Intellectual Property Law, a School of Water Resources, a School of Infrastructure Design and Management, a School of Engineering Entrepreneurship, a School of Energy Science, a School of Environmental Science and Technology, a School of Nano-Science and Technology and several sophisticated central facilities. It is the largest and the most diversified among all the IITs and continuously strives to produce scientists and technologists of the highest calibre and integrity to help the nation become self-reliant in its technological needs and to provide leadership in the field of technical education and research. Some of the distinctive features of the programmes at IIT Kharagpur are science based engineering education, emphasis on complete education, continuous internal evaluation and flexibility for experimentation, upgradation and innovation in curriculum design. IIT Kharagpur has a number of distinctions to its credit among all the IITs, such as the first Master's programme on Management, first Master's Programme on Medical Science and Technology for practicing Medical Doctors. In a study, sponsored by the Department of Science and Technology, Government of India, IIT Kharagpur is found to have the highest relative employment productivity index among the IITs and is the top supplier of fresh engineers/technologists to the public and private sector industries. It also ranked first among the IITs in the production of science and engineering Ph.Ds.

1.2 Academc Structure of the Institute

Number of Departments	: 20
Number of Centres	: 22 (Including 10 Nos. Centre of Excellence)
Number of Schools	: 11
Number of UG Programmes	: 17
Number of Dual Degree Programmes	: 17
Number of PG Programmes	: 54
Number of M.Sc. Programmes	: 09
Number of Law Courses	: 02

1.3 Postgraduate Degrees Conferred in the 2022

M.Tech.	: 802
MCP	: 50
MBA, EMBA	: 116
MMST, MHRM	: 30
LLB and LLM	: 43
Integrated M.Sc. (5 years)	: 205
MSc. (2 years)	: 219
Dual Degree	: 655
Ph.D. and MS conferred during the 69th annual convocation held on 18th December 2023	: 431

1.4 Central Library

Central Library, IIT Kharagpur is one of the largest technical libraries in Asia. The Central Library is having two buildings (main and annex) internally connected with a carpet area of about 8000 sq.m. All regular library services have been automated using integrated library management software 'LibSys7'. The library has 80 computer lab facility to access e-resources. Library also has 2000 seating capacity of students at a time. The Library has an excellent collection of over 4.2 lakh print documents along with 2.2 lakhs+ e-books (mostly from Springer Link, Wiley, Elsevier, ACS eBooks Archives, Gale Law eBooks, Cambridge University Press & Taylor & Francis) and full-text access to 26,500 e-journals from major publishers like Elsevier, Science, Springer, IEEE, IEE, ACM, ASME, Sage etc. Beside, Central Library also provides access to major bibliographical databases like SciFinder Scholar, Web of Science, Scopus, MathSciNet, financial databases (Capitaline, Bloomberg, Passport Euromonitor, CMIE's Industry Outlook, Prowess and CapEX,), Law databases (Westlaw, Manupatra, HeinOnline, WIPS) and standards (ASTM, BSI and ISO) so on and so forth. The Central Library has access to all Springer e-books (1850 to 2022), Wiley eBook (2016-2022) and Taylor & Francis (2003-2022) and many more e-books from other publishers. Library provides plagiarism check service through Turnitin software and grammar check service through digital library. Central Library has an excellent digital library section to facilitate seamless access to various subscribed e-resources through direct subscription as well as ESS Consortium. The Library has created Institutional Repository Server using DSpace software in order to preserve and provide access to intellectual output in terms of publications made by faculty, research scholars and others. The library has installed CCTV cameras in each of the reading halls and at strategic locations of Central Library buildings for auto-surveillance and security. The Central Library is also engaged for developing the National Library of India (NDLI) portal to provide single window access to all resources digitally available across all Institutions, Universities, Colleges in India. Recently Audio Visual Reading Lounge facilities have been created within central library to facilitate video conferencing and presentation, discussions etc. for the research scholars and faculty members. All such facilities including e-search, Web OPAC, news, events announcements, IDR etc. are available through library website https://library.iitkgp.ac.in to provide various library services to its users. Central Library is ISO 9001:2015 certified.

1.5 Center for Computational and Data Science (CCDS)

IIT Kharagpur hosts the PARAM Shakti supercomputing facility of 1 Peta-flop computing power under the National Supercomputing Mission (NSM), Govt. of India. This facility will accelerate and evolve the level of research currently being done with manifold improvement in output and efficiency. The research activities of CCDS will address building hardware and software for HPC systems, Data Management, Analytics, Visualizations, etc, along with promoting cutting-edge research in different HPC application domains that include but are not limited to Computational Biology, Drug Design, Atmospheric Modeling, Computational Fluid Dynamics, Geo-Scientific Computations, Modeling and Mining of Heterogeneous Information Network, Multi-scale Modeling of Novel Materials, Computational Chemistry, Computational Physics, Cryptanalysis, Numerical Mathematics, Computational Mechanics, Non-equilibrium Molecular Dynamics, etc.

Visit http://www.hpc.iitkgp.ac.in for more information about the infrastucture and its facilities.

1.6 Technology Students Gymkhana

The concept of the Technology Students' Gymkhana as a forum of Sports and Games, Social and Cultural, Technology and welfare activities, in which the students, the faculty, staff and their families can take deep interest is unique, and was introduced at IIT Kharagpur for the first time way back in the fifties. The Technology Students' Gymkhana is an organization for fostering and developing extra-curricular activities among the students. Through sports, games and cultural activities it helps to cultivate the spirit of constructive co-operation, leadership qualities and organizational abilities among the students. The Gymkhana is the nerve-centre of this residential campus and has enriched the quality of student life. Gymkhana has a large number of facilities that include a well-equipped modern Gymnasium, a standard swimming pool and three floodlit stadia, namely, Jnan Ghosh stadium, Tata Sports Complex and MG Ground for Hockey. Besides these, there are also floodlit Basketball, Volleyball, Table Tennis, Badminton and Tennis Courts. Club activities are also encouraged where students can display and develop their talents in various fields, e.g. photography, dramatics, social service, NSS, NCC, Yoga, etc. The Gymkhana also organizes annual social and cultural festival "Spring Festival", and Techo-Management festival "Kshitij", which are considered to be the largest of their kind in Asia in terms of student participation.

1.7 Accommodation and Amenities

The Institute is fully residential. Students are accommodated in 22 Halls of Residence, 14 for boys and 06 for girls and 02 with family accommodation for the Research Scholars/ Defence Personnel (M. Tech.). The halls have 24-hour internet connectivity. All the Halls of Residence also have regular catering facilities. Some additional food outlets are also located within the campus; a few late evening canteens are available as well in some of the Halls of Residence. Several restaurants including few air-conditioned ones and a Café Coffee Day, Subway, Mio Amore units are located in the campus, mainly in the hostel area. For daily necessities and groceries, one can walk down to the Technology Market (Tech. Market) within the Campus. Within 3-4 kms of the Institute, there are two big markets for shopping purpose. Three banks with ATM facility are located inside the Campus. The State Bank of India branch with core banking services is in the campus close to the Institute Main building and it provides foreign exchange facilities as well. Branches of State Bank of India, Punjab National Bank and Canara Bank along with their ATM counters are located within the campus. In addition, an Axis Bank ATM is available inside the Gymkhana premises. Post Office is located close to the State Bank of India branch. Outlets of a few courier services are also available within the campus.

South Eastern Railway has been operating a reservation counter in the Institute Main Building area extending Railway ticket booking facilities, especially to the students and the campus residents.

There are also a few privately run outlets in the campus to provide services for railway ticket booking, air ticket booking, car rental and STD / ISD phone calls.

1.8 Recreational/Extra Curricular Activities

IIT Kharagpur aims at the all round development of personality, with emphasis on physical, socio-cultural and value-oriented education. In the rich tapestry of culture that is the hallmark of this IIT, students play a vital role. They are an integral part of almost all decision-making bodies of the Institute, starting from hostel administration to Senate. They organize cultural and techno-management activities throughout the year, culminating in the Spring Fest and Kshitij. Technology Students' Gymkhana, the nerve centre for sports, cultural and social activities. It helps to cultivate the spirit of constructive co-operation, leadership qualities and organizational abilities among the students. It has a number of outdoor and indoor stadia for sports and games, a modern swimming pool and a gymnasium. Photography and Fine Arts Society, Music Society, Yoga Club, Film Society, Dramatics Society, Aquatics Society,

Robotix Society and many more special interest groups are supported by the Gymkhana. Lately a large number of technology and social service focused student societies have been formed, quite often as local chapters of reputed international bodies or societies. The halls of residence also offer a few in-house sports facilities in addition to the central facilities.

Visit https://gymkhana.iitkgp.ac.in for details of societies and clubs

1.9 Health Care

The B. C. Roy Technology Hospital is located at the center of the Campus. It provides indoor and outdoor medical facilities for common ailments. However, a few specialized visiting medical practitioners regularly attend the outdoor chambers. The Hospital has its round the clock emergency medical attendance arrangement, and a 24x7 medicine/Pharmacy counter. Complicated cases are referred for treatment to the State Hospital or to the Railway Hospital or to Hospitals in Kolkata. The Institute has Students' Medical Insurance Coverage which is obligatory on the part of the students and which usually covers a part of medical expenses for such referred cases. 24 hours Institute ambulance service is also available for the purpose of shifting the patients to other hospitals for better health management. A few specialized medical practitioners are also available around the IIT campus for private consultation; this list of neighbourhood medical facilities is posted at http://apna.iitkgp.ac.in/hospital.

1.10 Counselling Center

The Counselling Centre offers a broad range of services including psychological assessment, individual therapy, group therapy, as well as medication and management to promote mental health, life skills training, emotional resilience and overall well-being of the student community. Full-time counsellors and a visiting psychiatrist are available for consultation. The centre has also initiated an outreach program that involves building up a team of sensitized wing representatives from each Hall of Residence to help reach students in need.

1.11 Sponsord Research and Industrial Consultancy (SRIC)

The synthesis of teaching and research is fundamental to IIT Kharagpur. IIT Kharagpur is highly rated for the quality and breadth of its research enterprise, for the innovation of its faculty, for the excellence of its Ph.D programs, and for the amount of funding received in support of its research initiatives. IIT Kharagpur is noted for its openness to multidisciplinary research. Several new initiatives expand along IIT Kharagpur tradition of cross-disciplinary research and collaboration. The impact of this research is felt throughout India and around the world. IIT Kharagpur's research programs reach across the campus and beyond, linking together 19 departments, 16 academic centers and a large number of advanced R&D laboratories, stimulating the integration of inquiry, new knowledge, and education.

During the year 2014-2015 the Institute received from the Government, private and international funding agencies/enterprises 269 research projects for a total value of Rs. 149 crores and 125 consultancy projects worth Rs. 13 crores aggregating a total of 394 projects for Rs. 162 crores.

IIT Kharagpur is entrusted with the development of ASICs for the read out system for CBM experiment at the Facility for Antiproton and Ion Research (FAIR), Darmstadt, Germany, the new international accelerator facility and one of the largest research projects world-wide. IIT Kharagpur has a distinguished track record in the development of specialized software for power management, telemedicine, communication empowerment for physically challenged, software for medical measurements, tools for security and biometric authentication and ocean dynamics for storm surge measurements. An advanced research facility in reliability engineering with active participation of top government agencies including BARC has recently been created. Other examples of research in frontier areas include MEMS based components for RF application, development of functional groups for immobilization of functional proteins on MEMS based microsensor surfaces etc. IIT Kharagpur's pioneering works on advanced chip design and CAD for VLSI and MEMS continue to attract researchers and funding from the best institutes and

well-known companies of the world. In the past year the institute has started setting up of a major research infrastructure for MOCVD and initiated development of MBE cluster tool based epitaxial nano-semiconductor infrastructure and process integration facility.

In the areas of Life Sciences, ongoing interdisciplinary research in non-invasive measurements, advanced image processing, implants, protein structure analysis and drug design, merit special mention. The Institute has sustained activities in artificial heart development program, male contraceptive (RISUG), green technology, insect resistant cotton, enzymatic processes, Aloe Vera processing, and bio depolymerisation of low grade lignite.

The major research initiatives in nanotechnology and nano-materials include work on polymer nano-composites, nano-wires and semiconductors. The micro-fluidics and bio-nano-MEMS based techniques for DNA hybridization, micro-scale cooling for electronic components and digital micro fluidics are some examples of on-going cutting-edge research.

In the area of environment, the Institute has taken up a major initiative under the Ganga River Basin Management Plan funded by the Ministry of Environment and Forests to address issues related to environmental water quality, water resources management, ecology and bio-diversity as well as socio-economic policy, law and governance. In Earth Sciences, a major activity is undertaken for seismic hazard assessment, micro zonation and evaluation of vulnerability, risk & socio-economic impacts for the city of Kolkata. IIT Kharagpur has won one of the eleven IBM International Centennial Grants awarded this year for supporting its smarter planet strategies to community service.

IIT Kharagpur has continued its long standing research commitment to the Energy Sector through sustained activities in biomass production, bio-fuels, fuel cells, lithium-ion batteries and energy materials, production of renewable hydrogen combined with CO_2 capture etc. Our newly developed P. K. Sinha Centre for Bio-energy is taking an integrated and collaborative approach to solve energy, climate change and economic challenges, collaborating with internationally renowned Bioenergy Centers such as University of California at Berkeley (UCB) and Energy Biosciences Institute (EBI), Purdue University and University of California at Davis.

Industry – academia partnership at IIT Khargpur is thriving with industries forming partnerships in joint research projects, acquiring technologies developed in the institute and seeking consultancy supports. Some of the major research initiatives in recent years include Centre for Railway Research. Steel Technology Center, major R&D Centers in Energy Sector in collaboration with DVC, Tea Engineering Research Center, Vodafone-Essar-IIT Kharagpur Centre of Excellence in Telecommunications, National Program in Marine Hydrodynamics, Centre of Excellence in Information Assurance, National facilities for EPMA, General Motors Collaborative Research Laboratory in Electronics Controls and Software (ECS) and a Regional Center for Rural Technology Action Group (RUTAG) are some of the recent such successful initiatives.

1.12 Joint M.Tech./MCP/M.Arch. Programme of IIT Kharagpur

IIT Kharagpur invites applications for the Joint Masters and Ph.D. programme in Engineering, City Planning and Architecture for the admission year 2024-2025. This programme encourages bright and motivated students to enrol themselves for Ph.D after completion of first year of M.Tech/MCP/M.Arch programme.

Under this programme, at the end of first year, interested students having CGPA 8.0 and above are eligible to appear for written test and/or interview to judge their suitability to enrol for Ph.D. **Those who do not qualify for Ph.D. can continue with their two-year M.Tech/MCP/M.Arch programme.**

Students selected for Ph.D will have to complete the two year academic requirements of M.Tech/MCP/M.Arch programme before enrolment for Ph.D. For these students, the M.Tech/MCP/M.Arch and Ph.D degree will be awarded together upon successful completion of Ph.D. The programme is open to students of all categories with a Bachelor's degree in Engineering/-Technology/Architecture/MSc or equivalent professional degrees (AMIE etc.) and having a valid GATE score. Seats are reserved for OBC/EWS/SC/ST candidates and Persons with Disability (PwD) as per Government of India rules.

Two

Information About Various Departments/Schools/Centres

2.1 DEPARTMENT OF AEROSPACE ENGINEERING

Department of Aerospace Engineering, established in 1965, offers B. Tech, Dual degree and M. Tech programs in Aerodynamics, Control, Propulsion and Structures (starting). Active research programs leading to MS and PhD degrees also exist. The Department has many well-equipped laboratories in the areas of Aerodynamics, Structures and Propulsion, System and Control, and Intelligent Systems. Facilities in the Aerodynamics Laboratory include an airflow bench, subsonic wind tunnel, supersonic tunnel, supersonic jet facility, water tunnel, cascade tunnel and smoke tunnel etc. The other major wind tunnels include an industrial tunnel for studying wind effect on structures and a gust tunnel for studying unsteady flow problems.

Major Propulsion Laboratory facilities include Low speed axial flow compressor testing facility; Low speed contra rotating axial-centrifugal compressor testing facility- **THE ONLY FACILITY IN THE WORLD**; Low-speed linear Cascade testing facility; Annular Sector Cascade tunnel facility- **THE ONLY FACILITY IN INDIA**; Low speed Pressure probe calibration facility; Testing facility for development of new innovative turbine and compressor blade airfoils; Gas turbine film sweeping jet cooling testing facility; High speed contra rotating axial-centrifugal compressor testing facility for actual engines. **Scramjet Test facility is a major state-of-the-art facility related to supersonic combustion, which is developed in-house**. In addition, we have a state-of-the-art rocket test facility lab containing numerous test equipment and innovative test setups developed in-house. Moreover, a modern laser combustion research lab is also present. Besides, Propulsion Laboratory facilities include Axial Flow Fan Test Setup, Centrifugal Fan Test Unit, Contra rotating test facility, Ram Jet and Pulse Jet facility, Reaction Turbine Test facility, Nozzle Pressure Distribution Unit, Flame Propagation and Stabilization Unit, Nozzle Performance and Jet Reaction Unit and Droplet Combustion Test Rig.

Major flight Mechanics laboratory facilities include 2DOF Rotor System, Inverted Pendulum system, Magnetic Levitator System, Servo system, etc. A state-of-the-art lab exists for the guidance and control of UAVs and robots. A state-of-the-art laboratory exits for the satellite navigation system. The Department also has excellent computational laboratories equipped with high performance computational facilities besides a large number of workstations and high end PCs. The department also offers adequate facilities to the students to design, build and fly remotely controlled/auto-controlled model aircrafts including UAVs and MAVs.

The Structures Laboratory is equipped with electrodynamics vibration shakers, Multi-axis Shake table, a ten ton capacity universal testing machine, a torsion testing machine, computerized experiments related to deflection of curved bars, shear centre apparatus and buckling of struts having Interface for digital display of force, strain, deflection and angle with Experiment Software for each experiment, vibration fundamental kits (VFT). The Instron 1342 (upgraded model), servo-hydraulic materials testing machine with HP-300 High Speed Data Acquisition System for static, dynamic and fatigue testing of structural elements and Vibration Shake Table are excellent facilities in this department. The laboratory also

possesses photo elasticity unit with artificial vision system used for quality measurement in any point and suitable for the introduction and study of photo elasticity, pin jointed frameworks, virtual work and forces in truss (Resolution) with computerized digital display of force, strain, deflection etc. Uni-axial and Bi-axial test rigs for Plate Experiments incorporating parametric excitations and measurements are unique features of the Structures Laboratory. Application of Follower forces are also depicted in the laboratory experiments.

AE - Aerospace Engineering

Core Subjects: Aerodynamics, Aerospace Structures, Propulsion and Combustion, Flight Mechanic & Controls, Machine Computation Laboratory.

Elective Subjects: Computational Aerodynamics, Wind Tunnel Design and Testing, Computational Fluid Dynamics (CFD), Industrial Aerodynamics, Turbulence, Gas Dynamics, Hypersonic Aerodynamics, Advanced Viscous Flow, Introduction to Atmospheric Boundary Layer, Missile Aerodynamics, Aeroelasticity, Advanced CFD, Advanced Structural Dynamics, Experimental Stress Analysis, Fracture Mechanics, FEM in Aerospace Structures, Composite Structures, Smart Structures, Vibration Instrumentation and control, Plates and Shells, Nonlinear Vibration, Nonlinear FEM, Advanced Propulsion System, Combustion Process in Jet Engines, Aircraft Fuel Systems, Advanced Gas Turbine Theory, Advanced Air Breathing Propulsion, Automatic Control of Aircraft, Space Dynamics, Principles of Aircraft Design, Aircraft Conceptual Design, Neuro Fuzzy Control, Automatic Control of Aircraft, Satellite and Inertial Navigation Systems. etc.

Major Thrust Areas of Research:
(1) Unmanned Aerial Vehicles and related Technologies
(2) Smart and Composite Structure
(3) Experimental and Computational Research on Turbulent Flows
(4) Propulsion & Combustion, and
(5) Flight Dynamics & Control.

Detailed areas of Research: Computational Fluid Dynamics, Industrial Aerodynamics, Unsteady Aerodynamics, Drag Reduction, Turbulence, Aeroacoustics, Hypersonic Reacting Flows, turbulent reacting flows turbulence-radiation interaction, High performance computing, Flow-Induced Vibration and Fluid-Structure Interaction, DNS, LES, Structural Dynamics, Computational Structural Mechanics, Solid Mechanics, Aeroelasticity, Uncertainty Quantification in Aircraft Analysis and Design, FGM, Structural Health monitoring, Nonlocal Elasticity, Nano-composites, Multi-Scale Modeling, Injector Studies, Droplet/Spray Characterization and Burning, Propulsion systems for high speed flight, i.e., Scramjet Ramjet studies, Nanotechnology for Energy Applications, Supersonic Combustion Atomization and Sprays, Laser Spark, Combustion Driven Shock Tunnel, Spacecraft Dynamics and control, Intelligent Systems, Navigation (Aircraft and Satellite), System Identification/Parameter Estimation - Neural Networks, Inter Planetary Satellite Orbit Determination, Flight Testing , Micro Air Vehicle, development of liquid spray burner, laser diagnostic.

The Department is currently running a large number of sponsored research projects from different sponsoring agencies such as Aeronautics R & D Board, DRDO, DRDL, DST, Aeronautical Development Agency, Indian Space Research Organization, Indian Railway and others

2.2 DEPARTMENT OF AGRICULTURAL AND FOOD ENGINEERING

Among the IITs, only IIT Kharagpur has the distinction of having Agricultural and Food Engineering Department. The Department has been established on a broad pattern and takes up research in interdisciplinary areas with an integrated approach of science and technology. It has a wide-ranging postgraduate programme in six specializations and offers research programmes in diverse areas. The

undergraduate and postgraduate teaching is well established and has been well received by the industries and other organizations. The Department offers the following specializations at M.Tech. level:

AG1 - Farm Machinery and Power

AG2 - Land and Water Resources Engineering

AG3 - Food Process Engineering

AG4 - Agricultural Biotechnology

AG5 - Aquacultural Engineering

AG6 - Agricultural Systems and Management

Course Content:

AG1: Tractor Systems Design I and II, Farm Machinery Design and Testing, Soil Dynamics in Tillage and Traction, Alternative Energy Sources, Instrumentation and Research Techniques, Tractor Ergonomics, Precision Agriculture, Computer Aided Design of Tractors and Farm Machines, Artificial Intelligence (AI) Applications in Agricultural Mechanization, and Automation of Agricultural Machines.

AG2: Surface Water Hydrology, Advanced Groundwater Hydrology, Geo-Informatics for Land and Water Resources, On-farm Water Management, Water Resources Systems Analysis, Climate Change and Water Resources, Non-point Source Pollution and Management, Modelling and Simulation for Agricultural Water Management, Statistics of Hydroclimatic Extremes.

AG3: Food Chemistry, Advanced Mechanical Operations in Food Processing, Food Process and Products Technology, Advanced Thermal Operations in Food Processing, Transfer Process in Food Engineering, , Grain Process Engineering, Food Handling and Packaging, Grain Storage Principles and Structures, Advanced Food Technology, Food Process Modelling, Food Plant and Equipment Design, Instrumentation and Control in Food Industry, Non-thermal Processing of Foods, Fish Nutrition and Food Technology, Fishery Engineering.

AG4: Principles of Plant Breeding, Plant Metabolites and Separation Technology, Crop Breeding and Biotechnological Applications, Recombinant DNA Technology, Modern Genetics, Advanced Plant Physiology, Environmental Microbiology and Biopollution Control, Pharmacognosy and Metabolic Engineering, Seed Technology, Food Biotechnology.

AG5: Fishery Biology and Fish Culture Techniques, Open Channel Hydraulics and Coastal Engineering, Design of Aquacultural Facilities and Equipment, Planning and Design of Aquacultural Farms, Water Quality Management Practices, Principles of Fishing Technology, Advanced Aquaculture Technology, Processing and Preservation of Aquacultural Products.

AG6: Crop Production Systems, Soil Systems, Management and Productivity, Systems Approach in Agriculture, Agricultural Systems Modeling, Digital Soil Mapping, Soil-Plant-Water Relationships, Water Resources System Analysis, Climate Change and Agricultural Production System, Seed Technology, Organic Food Chain Management, Tea Science and Process Technology, Marketing of Food and Agricultural Products, Agro-Project Cash Flow Analysis and Finance.

Areas of Research: Tractor systems design, Modelling and performance simulation, Machine operators' safety and comfort, Precision agriculture and automation, Tillage and traction modelling, Combination tillage implements, Electronic Seed metering mechanisms, Solar, Wind and Biomass energy application, Alternate fuels, Drones and Robots in agriculture, Crop health and yield monitoring, and, AI and Machine Vision applications in agriculture.

Optimal control and decision support systems for irrigation projects, IoT and UAS for water and nutrient management, Hydrological modelling of agricultural watersheds, Integrated watershed management, Remote sensing and GIS for natural resources management, Irrigation systems modeling and management, Rainwater harvesting and artificial recharge, Basin-wide simulation-optimization modeling and field investigation (quantity and quality) of inland and coastal aquifer systems, River-aquifer and tide-aquifer interactions, Application of Geospatial and Multi-criteria Decision Analysis (MCDA) techniques for the integrated planning, development and management of groundwater and surface water resources, Evaluation of climate and socio-economic change impacts on inland and coastal groundwater resources, Automation of drip and sprinkler irrigation systems, Climate change, Crop modeling, Flood inundation modeling, hazard and risk analysis, Nanomaterial toxicity and risk assessment, Climate-water-energy nexus, Hydroinformatics, Statistical hydrology, Diffuse agricultural pollution, Applications of AI/ML in Land and Water Resources Engineering.

Osmo-air drying, Concentration and dehydration, Extrusion, Biomass and by-product utilization, Cryopreservation and cryogrinding, Expression and solvent extraction of vegetable oil, Parboiling and milling of paddy, UHT processing of milk, Biodegradable packaging film, Tea processing, Bioactives extraction and encapsulation, Vacum frying, Grain storage systems, Non-thermal processing of higher value perishables, Cold storage, Control atmosphere storage, Biosensors, CFD in Food Processing and Preservation, Machine vision and Image processing, Health Foods and Nutraceuticals, Microwave drying and heating systems, Heat transfer in non Newtonian Flow.

Plant tissue culture engineering, Plant molecular biology-biostress and plant signaling, Biotechnology of medicinal, aromatic and ornamental plants, Micropropagation and cryopreservation of medicinal plants, Screening and isolation of plant bioactive compounds, Molecular cloning of genes for plant secondary metabolites, Harnessing biodegradable polymers and bioactive compounds from microalgae, Production of microalgal fuels (biodiesel and bioethanol), Production of herbal and microbial-based biopesticides, Production of microbial and therapeutic enzymes, Microbial biotransformation of complex biopolymers to value added products, Waste water management.

Crop, water and nutrient uptake modeling & simulation; Organic farming and sustainable agricultural production; Soil and soil process assessment; Hyperspectral sensing; Digital soil mapping; Climate change adaptations & mitigations; Water and solute transport; Tea and betel leaf production & processing; Medicinal plants production & utilization; Economics of agro-production & processing, Agricultural cash flow and marketing management.

Fish biology, Resilient small-scale fisheries, Sustainable aquaculture, Brackish-water and inland aquaculture, Cage and raft culture, Raceways design, Intensive aquaculture, Aerator design, Sensor based water quality management, Aquaponics, Recirculatory aquacultural systems, Design and development of aquacultural production and processing equipment.

2.3 DEPARTMENT OF ARCHITECTURE AND REGIONAL PLANNING

The Department of Architecture and Regional Planning was established in 1952 in this Institute, and has been involved in teaching and research in the areas of Architecture, Regional Planning, and City Planning. It is recognized as one of the leading departments in the Country offering undergraduate, post-graduate and doctoral programmes.

The Department currently offers following postgraduate courses:

AR1 - City Planning

AR2 - Sustainable Build Environment

AR1 - City Planning

City planning has been described as the art and science of ordering the use of Land and siting of buildings and communication routes so as to secure the maximum degree of economy, convenience and beauty, whose main impetus is thus "foreseeing and guiding change." Thus City Planning is a process of formulating a plan, which narrates a blue –print of actions and decisions to reach a predetermined goal, within a predicted period of time. The city planning course offered here is unique. On one hand it is broad based, exposing students to grasp complex issues of urban development, surveying techniques, analytical tools, decision making processes and management techniques. On the other hand is devoted for in depth learning and specialisation, spending considerable time in seminars, viva-voce and preparing dissertation thesis. The academic input among others, focuses on issues related to, Socio-Economic and Physical Aspects of Human Settlements, Housing, Transportation Planning, New Town Planning, Urban Revitalisation and Conservation, Utilities and Infrastructure Planning, Development Economics, Environmental Planning, Urban Design, Landscape Planning, GIS and Remote-sensing, Tourism and Recreation Planning.

Course Content:

The Core Courses are: Planning History and Principles, Quantitative Methods, Transportation Planning, Housing and Community Planning, Dynamics of Settlement Systems, Remote Sensing and GIS in Planning, Utilities and Services Planning, Planning Legislation and Professional Practice, Development Management and Finance, GIS Lab, Planning Workshop I and II (including Two-week field study in each).

Depending on their interests, the students are required to take up three Depth Elective Courses in the third and fourth semesters. The electives are as follows:

Advanced Transportation, Urban Conservation, Environmental Planning, Landscape and Recreation Planning, Regional Analyses and Programming, Urban Design, Advanced Quantitative Methods in Planning, Planning Theory, Planning Informatics, Social Aspects of Human Settlements, Disaster Management.

The students are also required to take up an eight weeks summer-internship. This would be undertaken in any leading planning organization, development authority, or planning laboratory. The Department provides assistance in organizing the training programme. Seminars, presentations and group-discussions are regular components of the course. The students finally work on a dissertation on an area of their interest, and defend it through the final viva-voce.

Areas of Research:

Urban Fringe Areas, Housing and Community Planning, Urban Open Spaces, Transportation Planning, Watershed Management, Heritage Studies and Conservation, Infrastructure Planning and Systems Management, Computer Applications in Architecture and Planning, GIS and Remote-sensing Applications. The Department is engaged in various live projects on urban planning.

AR2 - Sustainable Build Environment Sustainable designs are a good response of the thankful heart to the fact that humans have received all for their healthy existence and evolution from nature. The role of architects in facilitating sustainability through built forms is essential to a fast-developing nation like India. Therefore, it is inevitable and high time that an appropriate postgraduate programme in architecture, specifically in sustainable built environments, is offered at our prestigious and pioneering Department to generate well-equipped professionals to deal with the sustainability needs in built forms. The advanced design-oriented programme is conceived as a regular four-semester postgraduate program. The program intends to prepare dynamic, professional designers equipped with the knowledge of the state-of-the-art technology through intensive training and project work.

Course Content:

The Core Courses are: The Core Courses are Sustainable Built Environment Design Principles, Cultural Systems and Alternative Concepts, Sustainable Material, Sustainable urban Architecture, and

Integrated Design Simulation Lab I & II. The course will allow flexibility with choice of depth elective courses. Depending on their interests, student will take up five Depth Elective Courses from first semester.

The students are also required to take up an eight-week summer internship in any leading organization, development authority, or laboratory.

The Department assists in organizing the training programme. Seminars, presentations and group discussions are regular components of the course. The students finally work on a dissertation on an area of their interest and defend it through the final viva-voce.

Areas of Research:
Sustainability, Rating systems, Passive energy systems, Water and Waste Management, Energy and Building integrated systems, Advanced Construction Techniques, Digital Fabrication, Biomimicry, Vernacular sustainable systems, Design and Climate Change, Designing Low-Carbon and Carbon-free environments, Application of Artificial Intelligence and Machine Learning in Design and Architecture.

2.4 DEPARTMENT OF BIOSCIENCE AND BIOTECHNOLOGY

IIT Kharagpur launched its Biotechnology program way back in 1986 through the introduction of an M. Tech Course in Biotechnology & Biochemical Engineering with generous support from the Department of Biotechnology, Government of India. Since the program bred excellence in all spheres of teaching / training and research, there was wide appreciation of the program which thereby led to the introduction of an undergraduate course in Biotechnology and Biochemical Engineering in 1994, and an independent Department in 1999. Department of Biotechnology and School of Bioscience merged into a single Department in 2023 and reorganized the teaching and research activities keeping in mind with the rapidly evolving areas of Biological Sciences and Engineering to achieve excellence. The Department currently offers B. Tech (Hons.), Integrated B. Tech-M. Tech dual degree, Integrated M. Tech-PhD, Joint MSc-PhD program on Chemical and Molecular Biology (in collaboration with Indian Association for the Cultivation of Science, Kolkata), and PhD programs as well as, opportunities for post-doctoral research. The M. Tech program offers balanced exposure to theoretical and practical aspects of modern Biological Sciences and Bioprocess Engineering. Oratory and presentation skills as well as knowledge of recent research advances are developed through paper presentation classes. In addition, the students get hands-on experience in research through M. Tech dissertation work that are undertaken in the second year of the program. The Department has state-of-the-art facilities in Recombinant DNA Technology, Biochemical Engineering, Bio-separation Technology, Bioprocess Technology, Cell and Molecular Biology, Structural Biology (Macromolecular crystallography), Systems Biology, Plant Biotechnology, Biochemistry, Bioinformatics, Applied and Environmental Microbiology, Immunotechnology, Molecular Genetics, Proteomics and Genomics. The faculty has strong interaction with reputed Institutions nationally and internationally. The achievements in Research outcomes, Industry-Institute collaborative R&D, process / product / equipment development, patent and technology transfer on inventions are indicative of the excellence of the program.

The Department offers M.Tech degree in:

BT - Biotechnology and Biochemical Engineering

Course Content:
Core Subjects: Aspects of Biochemical Engineering, Bioseparation Technology, Recombinant DNA Technology

Electives: Bioprocess Plant and Equipment Design, Protein Engineering, Animal cell culture and immunotechnology, Transgenic Technology, Introduction to Systems Biology, Microbial genomics & metagenomics, Gene expression, Biotechnology of plant metabolites, Computational structural biology, Process modelling and simulation, Secondary Metabolism in Plants and Microbes etc.

The core theory courses are adequately supported by well-planned laboratory courses in Bioprocess Technology, Bioseparation Technology and Recombinant DNA Technology.

Areas of Research:
Recombinant protein production in plant, animal and microbial cells; Healthcare and nutraceutical biotechnology, Production and analysis of transgenic plants; Bioprocess & Bioproduct Development; Bioprocess modelling & optimization; Microbial & microalgal biorefinery; Biofuels & value added products; Biological carbon capture & waste valorization; Microbial fuel cell; Marine biotechnology; Environmental Biotechnology; Gene expression in prokaryotic and eukaryotic systems; , Proteomics and protein-protein interaction; Metagenomics; Geomicrobiology; Bioremediation; Functional genomics of bacterial cell wall; Mechanisms of antimicrobial resistance; Bacterial biofilm formation and its inhibition; Structural Biology and protein crystallography of important proteins from M. tuberculosis and S. aureus; Structure based inhibitor/drug design; Structural bioinformatics. DNA repair mechanisms in response to topoisomerase I poisoning, DNA repair mechanisms in kinetoplastid parasites, Regulation of gene expression in protozoan parasite *Entamoeba histolytica* and *E. invadens*. Study of signal transduction in trophozoite and encysting *Entamoeba*. Systems biology encompassing study of antibiotic resistance evolution; Non-genetic variations and design of synthetic circuits for bio-applications, Infection biology and Host pathogen interaction in context of mycobacterial pathogenesis and development of POC diagnostics and host-directed therapeutics against tuberculosis.

Link to Department profile: http://bt.iitkgp.ac.in
Link to M. Tech curriculum:
https://erp.iitkgp.ac.in/ERPWebServices/curricula/CurriculaSubjectsList.jsp?stuType=PG&splCode=BT

2.5 DEPARTMENT OF CHEMICAL ENGINEERING

Welcome to the Department of Chemical Engineering at the Indian Institute of Technology (IIT) Kharagpur. Established in 1951 under the leadership of Professor Weingaertner, ours is the first Chemical Engineering Department to be set up in an IIT. As per the most recent QS World University Ranking (2023-24) we are ranked 100 globally and are fifth in the Asian University ranking. Our total student strength including UG, PG and doctoral students is 836 with 544 undergraduate students and 167 M.Tech. students. Around 130 undergraduate students graduate (including dual degrees) graduate per year. We have also hosted several international students as summer interns and post graduates over the past few years. Currently, our department has 27 faculty members, 125 doctoral students, with research covering diverse areas of basic and applied chemical engineering, as well as those at the interface with other areas of science and engineering. A glimpse at our faculty profile on the departmental website (http://iitkgp.ac.in/department/CH) reveals the diversity of current research areas in the Department. They range from nano and molecular to pilot plant scales, in areas of Environmental Pollution Control; Polymer Processing and Composites; Plasma Engineering and Surface Science; Computational Materials Science; Colloid and Interface Engineering; Molecular Simulation; Computational Fluid Dynamics and Thermal Engineering; Catalysis and Reaction Engineering; Bioenergy; Bioprocess Engineering and Biofuels; Surface science and Nanotechnology Carbon Capture and Storage; Fine Particle Engineering; Crystallisation Engineering; Process Optimization, Dynamics and Control; Membrane Separation; Bio- and Energy Materials; Soft Nanotechnology; Complex Fluids; Microfluidics and Microscale Transport Engineering; Porous Media and Structured Fluids; Micro-scale Heat Exchange; Reaction Engineering and Chemical Process Development, Petroleum Refining and Petrochemicals; Multiphase Flow.

The Department offers M.Tech degree in:

CH - Chemical Engineering

Core subjects: Advanced Fluid dynamics, Advanced Mass Transfer, Advanced Heat Transfer, Process Dynamics and Control, Advanced Mathematical Techniques in Chemical Engineering.

Elective subjects: A host of elective subjects are also offered as part of the program for a comprehensive development of the students. These include Optimization Techniques in Process Design, Process Modelling and Simulation, Industrial Pollution Control, Petroleum Refinery Engineering, Advanced Thermodynamics, Multiphase Flow, Reservoir Engineering, Green Technology, CFD Applications in Chemical Processes, Computational Modeling of Multiphase Reactive Flows. Microscale Transport Process, Transport in Porous Media, Polymer Engineering, Energy Conservation in Process Industries, Chemical Engineering Principles in Polymer Processing. Rheology, Advances in Biochemical Engineering, Novel Separation Processes, Petrochemical Technology, Chemical Reactor Analysis, Computer Process Control, Project Engineering and Management, Manufacturing and Characterization of Polymer Matrix Composites, Hazardous Waste Treatment and Management. Our department houses state-of-the-art computing facilities as well as instruments including XRD, XRF, FESEM, AFM, AAS, FTIR,DLS, CHNS Analyzer, HPLC, LC, GC, IC, UTM, TGA, BET-BJH Analyzer, Particle Size Analyzer, Micro PIV etc. Our department has been engaged in industrial research sponsored by notable organizations, such as Rungta Mines Ltd., Larsen Toubro,, SAIL, Tata Steel, DRDO, AERB, ONGC, BHEL, Essar Steel, Indian Oil Corporation, CMPDE, CECB, CPCB, DST, DBT, Coal India Limited, IOCL, etc. FCC Riser Hydrodynamic Studies, Catalyst Development, Process Development for Alkylation of Aromatics, Coke Oven Effluent treatment, On-line polymerization process optimization, Heat Pipe Performance Simulation, Pollution Load Carrying Capacity etc. The National Bio-gas project and the removal of hazardous impurities such as arsenic from drinking water at an industrial scale were undertaken to serve rural India. Every year the faculty members of the Department file several patents and commercialise technologies through technology transfer. Our department has offered an Executive M. Tech Program in collaboration with ICT, Mumbai for industry professionals and conducts frequent short-term courses for industry professionals. Several international collaborations through Memorandum of Understanding are ongoing with University of Oxford, UK, University of Houston, USA, and University of Newcastle and Curtin University, Australia. Every year several of our doctoral and post-graduate students present their research at international conferences such as AIChE Annual Meeting, Asia-Pacific Confederation of Chemical Engineering Congress, World Congress of Chemical Engineering, Euro-membrane, ISCRE, European Congress of Chemical Engineering, etc. We endeavour to offer the right balance between basic and applied research to hone our students with the core competency they would need to excel in their future careers in industry and academia.

2.6 DEPARTMENT OF CIVIL ENGINEERING

The Civil Engineering Department started to function in August 1951 from the historic Hijli Detention Camp to train young engineers in this profession of socio-economic relevance. The early philosophy of the department towards teaching was to encourage a practical ‘Hands-on’ approach to engineering. The current vision of the department is also to impart advanced education with an appropriate blend of theory and practice to the M Tech students.

The students, faculty members and the staff members of the department have been making major research contributions in different fields of civil engineering which led to the department being identified as one of the top two civil engineering departments in India with the highest number of research publications per faculty and with the highest H-index during 2001-2015.

The department currently offers M Tech programmes in the following five specializations.

CE1 - Hydraulic and Water Resources Engineering

CE2 - Transportation Engineering

CE3 - Environmental Engineering and Management

CE4 - Geotechnical Engineering

CE5 - Structural Engineering

Course Content:

CE1 (Hydraulic and Water Resources Engineering): Free surface flow; Applied hydrology; Advanced Hydraulic structures; Viscous fluid flow; Geohydraulics; Geoinformatics for land and water Resources; Advanced computational hydraulics; Hydraulics of sediment transport; Turbulent fluid flow; Integrated watershed management; Hydropower engineering; River engineering.

CE2 (Transportation Engineering): Pavement Materials; Analysis and Design of Pavements; Pavement Construction; Pavement Evaluation and Rehabilitation; Geometric design of transportation facilities; Transportation System Planning; Transportation Economics; Transit Planning and Operation; Traffic Engineering; Design and Planning of Airports; Analysis of Transportation systems.

CE3 (Environmental Engineering and Management): Water Supply Systems; Wastewater Management; Industrial Water Pollution Control; Solid Waste Management; Air Quality Management; Environmental Impact Assessment; Environmental Management; Environmental Chemistry and Microbiology; Advanced water and waste water treatment; Hazardous waste management; Environmental hydraulics.

CE4 (Geotechnical Engineering): Soil Exploration-planning and methods; Characterization of soils; Basic Geo Mechanics; Applied Soil Mechanics; Foundation Engineering; Soil Structure Interaction; Soil Dynamics and Earthquake Engineering; Rock mechanics and Tunnelling; Computational Geomechanics; Behaviour of Unsaturated Soil; Ground Improvement; Offshore Geotechnical Engineering; Optimization.

CE5 (Structural Engineering): Advanced Structural Analysis; Elasticity, Plasticity and Visco-elasticity; Elastic Stability; Reinforced Concrete Structures; Metal Structures; Pre-stressed Concrete; Composite Structures; High-rise Structures; Random Vibration and Earthquake Resistant Structures; Shell Structures; Probabilistic Design; Optimization; Offshore Structures; Computational Mechanics; Finite Element Analysis; Construction Management and Planning; Bridge Engineering; Structural Health Monitoring and Control.

Broad Areas of Research:

Hydraulic and Water Resources Engineering: Sediment Transport and Jet Diffusion; Flood forecasting; Clear water scour; Mathematical modelling of unsteady flow on fluvial beds; Bridge pier scour and confluence scour; Surface water and ground water hydrology; Climate impact on Hydrology and Water Resources; Stochastic hydrological analysis Hydrologic extreme analysis (Droughts and Floods); Drought analysis; Numerical models for free surface flow; Physical models of hydraulic structures; Resource mapping and flood analysis using remote sensing and GIS; Application of Artificial Intelligence techniques in water resources engineering; ; Ground water engineering.

Transportation Engineering: Planning of rural and urban transport systems; Design and Management of Transportation Systems; Road traffic safety; Travel behaviour modelling; Traffic flow simulation; Development of new pavement materials; Modification and evaluation of bituminous binders using polymers and waste rubbers; Pavement analysis and design; Non-destructive evaluation of pavements

Environmental Engineering and Management: Environmental impact assessment; System analysis and water quality management; mathematical modelling of river and estuarine pollution control; bio-reactors; water-hyacinths and aquatic weeds for pollutant removal; Water distribution networks; Physico-chemical process for water and waste water treatment; Solid waste management, Heavy/trace metal removal, Industrial air pollution and control; Rural Water Supply; Aerobic/anaerobic treatment of waste waters; Pesticides removal and degradation; Bio-filtration for air pollution control; Process modification for pollution minimization. Environmental life cycle assessment

Geotechnical Engineering: Disaster Mitigation; Characterization of Insitu Geomaterials; Geomechanics Material Research; Reliability in Gotechnical Engg; Pile foundations; Soil Dynamics; Computational Geotechnical Engineering; Seismic Analysis of Underground Structures; Soil Stabilization; Geotechnical Earthquake Engineering; Reinforced Soil Structures; Shallow foundation; Soil-Structure Interaction; Ground Improvement; Foundation on Soft Soil; Landslide Hazard Mitigation

Structural Engineering: Improved Structural stability; Reliability based design; Structural Health Monitoring; Disaster Resistant Structures; Structural Retrofitting; Structural Fire Engineering; Bridge-vehicle interaction; Recycled Aggregates for Concrete; Bamboo-reinforced concrete; Fiber Reinforced Polymer (FRP) to prolong life of concrete structures; Conservation and safety assessment of historic structures; Improved armour materials for ballistic impact; Improved sandwich composites; Molecular dynamics and nano-scale simulations to explain structural response; Meso mechanics based studies of concrete

2.7 DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

The Department of Computer Science and Engineering at the Indian Institute of Technology Kharagpur, was formed in 1980. Since its inception, the department has been recognized all over the world for excellence in research and teaching. The department has a thriving research environment with active research groups in the areas of Algorithms and Theory, Artificial Intelligence and Machine Learning, Bioinformatics, Cryptography and Security, Complex and Social Networks, Data and Web Mining, Formal Methods, Image Processing and Computer Vision, Natural Language Processing, Software Engineering, and Systems and Networking. Graduates from the department have excellent placement records, and many ex-students of the department occupy top positions in both academia and industry all over the world.

The department provides excellent facilities for MTech students. The course work is rigorous. The curriculum includes three rigorous core theory courses and two rigorous core lab courses to lay strong foundations for the students. There is a wide variety of specialized electives encompassing many areas of Computer Science. The MTech project requires the student to spend one year on a substantial research topic and often leads to very significant research and development work. There are good opportunities to do collaborative project work with industry.

CS - Computer Science and Engineering

Course Contents:
Core Courses: Algorithm Design and Analysis, Foundations of Computing Science, High Performance Computer Architecture, Computing Lab, Design Lab, Seminar, Project.

Elective courses (not exhaustive): Artificial Intelligence, Machine Learning, Advanced Machine Learning, Deep Learning, Statistical Learning Theory, Scalable Data Mining, AI and Ethics, Speech and Natural Language Processing, Advanced Digital Image Processing and Computer Vision, Complex Networks, Information Retrieval, Intelligent Systems, Social Computing, Reinforcement Learning, Scalable Data Mining.

Cryptography and Network Security, Hardware Security, Foundations of Cryptography, Usable Security and Privacy, Theory and Applications of Blockchain.

Advanced Graph Theory, Computational Complexity, Computational Number Theory, Logic for Computer Science, Principles of Programming Languages, Computational Geometry, Parallel Algorithms, Randomized Algorithms, Selected Topics in Algorithms, Approximate and Online Algorithms, Algorithmic Game Theory.

Distributed Systems, Database Engineering, Object Oriented Systems, Internet Protocols and Applications, Advances in Operating Systems Design, Cloud Computing, Real Time Systems, Fault Tolerant Systems, Geographical Information Systems, Embedded Systems, Smartphone Computing and Applications, Ubiquitous Computing, Theory and Applications of Blockchain, Testing and Verification of Circuits, VLSI System Design, CAD for VLSI Design, Low Power Circuits and Systems.

Algorithms for Bioinformatics, Computational Biophysics: Algorithms to Applications, High Performance Parallel Programming.

Areas of Research: Algorithms and Theory, Artificial Intelligence and Machine Learning, Bioinformatics, Cryptography and Security, Complex and Social Networks, Data and Web Mining, Formal Methods, Image Processing and Computer Vision, Natural Language Processing, Software Engineering, Systems and Networking.

2.8 DEPARTMENT OF ELECTRICAL ENGINEERING

The first postgraduate programme started in the department was on "Electrical Machines" in 1955, followed by "Control Systems" in 1959. With the establishment of a Power Electronics Laboratory in 1972, the courses under "Electrical Machines" were updated and the programme was redesignated as "Machine Drives and Power Electronics" in 1981. The third programme on "Power Systems" was introduced in 1965, which has now been redesignated as "Power and Energy Systems" since 2010. The programme on "Instrumentation" which started in 1972 was revised in 2012 and renamed as "Instrumentation and Signal Processing." In 2022, this was reconfigured as "Instrumentation and Integrated Electronics." A separate programme on "Signal Processing and Machine Learning" was introduced in 2022.

The department offers the following five programmes for the M. Tech degree:

EE1 - Machine Drives and Power Electronics

EE2 - Control System Engineering

EE3 - Power and Energy Systems

EE4 - Instrumentation and Integrated Electronics

EE5 - Signal Processing and Machine Learning

Course Contents:

Core Courses:

EE1: The subjects presently offered are: Switched Mode Power Conversion, Dynamics of Electric Machine and Control, Advanced Machine Drives, Soft Switching Converters, Multilevel Converters, Power Electronics Laboratory and Machine Drives Laboratory.

EE2: The subjects presently offered are: Linear Systems and Control, Probability and Random Processes for Signals and Systems, Optimal Control, Nonlinear Systems and Control, Modeling and Identification, Control Systems Laboratory, Control Design and Implementation Laboratory, Embedded Control Laboratory.

EE3: The subjects offered are: Renewable and Distributed Energy Systems, Power System Analysis and Operation, Power System Protection, Power System Dynamics and Control,, Power and Energy Systems Laboratory and Power and Energy Systems Design Laboratory.

EE4: The subjects offered are: Analog Signal Processing, Sensors and Measurement Technology, Mixed Signal Circuits and System-on-Chip, Advanced Sensing Techniques, Embedded Systems Laboratory, Instrumentation Laboratory, Mixed Signal VLSI Laboratory, Instrumentation System Design Laboratory.

EE5: The subjects offered are: Linear Algebra for Signals and Systems, Probability and Random Processes for Signals and Systems, Machine Learning for Signal Processing, Statistical Signal Processing, Convex Optimization for Control and Signal Processing, Signal Processing Systems Design Laboratory and Machine Learning for Signal Processing Laboratory.

In addition to the "core" subjects mentioned against each specialization above, the Department offers a large number of elective subjects. Some of the electives are: Electric Vehicles, Special Electrical Machines, Wind Energy, Nonconventional Electrical Energy Systems, Intelligent Control, Robust Control, Digital Control, HVDC and FACTS, Artificial Intelligence applications to Power System, High Voltage and Insulation Engineering, Industrial Applications of High Voltage Engineering, Industrial Automation and Control, Model Predictive Control, Digital Control, Intelligent Control, Robust Control, Geometric Control Theory, Adaptive and Learning Control, Process Monitoring and Fault Diagnostics, Fractional Order Devices and Circuits, Biomedical Instrumentation, Automotive Sensors and Instrumentation, Real-time Systems, Computational Methods and Algorithms in Signal Processing, Digital Image Processing, Biomedical Signal Processing, Advanced Digital Signal Processing, Time-Frequency and Multi-Resolution Signal Analysis, Distributed Signal Processing in Sensor Networks, Advanced Estimation Theory, Geometric Methods of Computer Vision, Medical Image Analysis, etc.

In addition, students can choose appropriate elective subjects from other departments i.e. Computer Science and Engineering, Electronics and Electrical Communication Engineering, Mechanical Engineering, Aerospace Engineering, Mathematics, School of Medical Science and Technology, G. S. Sanyal School of Telecommunication, S. Chowdhury School of Quality and Reliability and Materials Science Centre.

Areas of Research: The current research activities in the Department are mainly centered on the following areas:

Machine Drives and Power Electronics: DSP / FPGA-based controllers for induction and synchronous machines, parameter-adaptive controllers for indirect field-oriented AC motor drives and speed sensor less operation, direct field orientation of induction motors with rotor flux observers, matrix converter fed drives, power converter topologies for medium voltage drives, variable speed constant frequency wind power generation systems, modular multilevel converter, power converters for grid interactive photovoltaic power generation, linear induction and synchronous machine-based propulsion systems, electric vehicle propulsion systems, VLSI-based design of DC-DC converters, analysis of bifurcation in power electronic converters.

Control System Engineering: Control and optimization of linear systems, neural networks for control and system studies, model order reduction, nonlinear dynamical systems, robust control, fuzzy control, sliding mode and variable structure control, large scale systems, fractional order systems, genetic

algorithm applications in control, periodic controllers, decentralized control, systems with time delay, discrete event systems, fault tolerant control, networked control systems as well as control applications in automotive, power converters and (unmanned) aerial vehicles.

Power and Energy Systems: Optimal load-flow studies, Load forecasting and contingency analysis, Stability analysis of large interconnected power systems, Power System Protection, Fiber optic and other optoelectronic CTs and PTs for power systems, Wide Area Measurement System, Smart Grid, High Voltage Engineering, Condition monitoring of power transformers and other equipment, Flexible AC Transmission Systems, HVDC transmission systems, Electric Power Distribution System, Non-conventional energy sources (wind and solar) and their Grid integration, Microgrid Operation.

Instrumentation and Integrated Electronics : Sensors Development, Electrochemical sensor, Optoelectronic sensor, MEMS and Mixed Signal VLSI, Power Management IC, Energy Harvesting, Interfacing Electronics, Embedded Systems.

Signal Processing and Machine Learning: SComputer Vision and Visualization, Medical Image and Information Processing, AI and Machine Learning, IoT and Embedded Processing, Audio, Acoustics and Speech Processing.
The details are available here: http://ee.iitkgp.ac.in

2.9 DEPARTMENT OF ELECTRONICS & ELECTRICAL COMMUNICATION ENGINEERING

The Department of Electronics and Electrical Communication Engineering (E&ECE), IIT Kharagpur was established right at the inception of the institute in 1951. In its initial years, the department's activities were restricted to research, primarily fulfilling the country's needs. Thereafter undergraduate studies started and the students used to receive B. Tech (Hons.) degree in Electrical Engineering and the subjects on Electronics were offered in the final year. As the area grew further, from 1958 the Institute started offering B. Tech (Hons) degree in Electronics and Electrical Communication Engineering. Since its inception, the E&ECE department of IIT Kharagpur has been a pioneer in introducing subjects in the fields of Communications, Microwave and Computer Engineering. The department has been involved in teaching and research in diverse aspects of Telecommunication, Microelectronics, Computer Vision, Electromagnetics, and Light wave Engineering.

The Department offers M. Tech degree in:

EC2 - Microelectronics and VLSI Circuits

EC3 - RF and Microwave Engineering

EC4 - Communications and Signal Processing

EC5 - Vision and Intelligent Systems

Course Content:

EC2: This specialization has five core theory subjects, namely, 'Advanced Semiconductor Devices', 'VLSI Process Technology', 'Analog and Mixed Signal Circuits', 'Digital VLSI Circuits', and 'CAD for VLSI'. Additionally, there are three core laboratory subjects, namely, 'VLSI Circuits and Systems Laboratory', 'VLSI Technology and Process Modelling Laboratory', and 'VLSI Design Laboratory'. The program has a seminar in the first semester, and a summer internship after the first year. There are two

pathways, which a student can choose for the completion of the degree. In IR pathway, there are five depth electives and one breadth elective. In PP pathway, there are four depth electives and two breadth electives. The M.Tech project starts in second semester.

EC3: This specialization has five core theory subjects, namely, 'Advanced Electromagnetic Engineering', 'Analytical and Computational Techniques in Electromagnetics', 'Active and Passive RF components', 'Antenna Theory and Practice', and 'Microwave and Millimeter wave Integrated Circuits'. Additionally, there are three core laboratory subjects, namely, 'RF and Microwave Circuits Laboratory', 'Antenna and EMI/EMC Laboratory', and 'RF Design Laboratory'. The program has a seminar in the first semester, and a summer internship after the first year. There are two pathways, which a student can choose for the completion of the degree. In IR pathway, there are five depth electives and one breadth elective. In PP pathway, there are four depth electives and two breadth electives. The M.Tech project starts in second semester.

EC4: This specialization has five core theory subjects, namely, 'Advanced Digital Communication', 'Statistical Signal Processing', 'Communication Networks', 'Information Theory and Coding', and 'Wireless Communication'. Additionally, there are two core laboratory subjects, namely, 'Design and Simulation Laboratory: Communication Systems', and 'Design and Simulation Laboratory: Communication Networks'. The program has a seminar in the first semester, and a summer internship after the first year. There are two pathways, which a student can choose for the completion of the degree. In IR pathway, there are five depth electives and one breadth elective. In PP pathway, there are four depth electives and two breadth electives. The M.Tech project starts in second semester. **EC5:** This specialization has five core theory subjects, namely, 'Foundations of Learning Theory', 'Image and Video Processing', 'Pattern Recognition and Machine Intelligence', 'Vision and Visualization', and 'Deep Learning'. Additionally, there are two core laboratory subjects, namely, 'Image and Video Processing Laboratory', and 'Intelligent Systems Design Laboratory'. The program has a seminar in the first semester, and a summer internship after the first year. There are two pathways, which a student can choose for the completion of the degree. In IR pathway, there are five depth electives and one breadth elective. In PP pathway, there are four depth electives and two breadth electives. The M.Tech project starts in second semester.

Depth Electives: Digital Signal Processing and Applications, Computer Communication and Networking, Embedded Systems, Data Structure and Object Representation, Neural Networks and applications, Computational Neuroscience, Advanced Computer System Architecture, Systems Biology: Modelling and Control, Digital Voice & Picture Communication, Optical Communication, Architectural Design of ICs, Satellite Communication Systems, VLSI for Telecommunication, Fibre Optics, Components and Devices, VLSI Interconnects, Advanced Operating Systems design, Biomedical Systems Engineering and Automation, Radar signature Analysis and Radar imaging, Multimedia Systems and Communication, Adaptive Systems and Signal Processing, Neuronal coding for sensory information, Speech and Audio Signal Processing, Internet of Things, RF and Microwave Networks, EMI / EMC Techniques, VLSI Data Converter Design, Lightwave Networks, Millimeter Wave Technology, Nanoelectronics, Mixed-Signal and RF Design, Secure Communication, Integrated Nano photonics, Linear Algebra and Error Control Technique, Technology CAD, Transport Phenomena in Mesoscopic and Nanoscopic Systems

Areas of Research:

The research activities can be grouped under several major areas as mentioned below:

Microelectronics and VLSI Circuits (EC2): Spintronics, MEMS, VLSI architecture design, Mixed signal VLSI design, Real-time Architectures for Image and Video Processing, Design automation of analog circuits, Interface circuits in high-speed link, On-chip power management circuits, Circuits in signal acquisition front-end, Sensor on CMOS-MEMS platform, Metal oxide/2Dlayered mat. gas sensor, super capacitor, Quantum photonics, Fiber optics and photonics, Nanophotonics, Nanofabrication.

RF and Microwave Engineering (EC3): Electromagnetics, Microwave imaging, Microwave Antennas, RF and Microwave Integrated Circuits, Millimetric Waves, Magnetostatic Waves, Microstrip Antennas, Phased Array Antennas, EMI/EMC/PSD, Microwave and Millimeterwave Systems and Propagation, Computational Techniques, Radar Cross Section, Ground Penetrating Radar.

Communications and Signal Processing (EC4): Wireless communication, Information theory, Communication and control, Coding theory, Signal processing for communication, Wireless networks, Multimedia communications and systems, UAV networks, Network security, adaptive signal processing, VLSI signal processing, Compressed sensing, Applied linear algebra, Physical layer security, Dual functional Radar communication, MIMO communication, Index modulation, Speech processing, Satellite Communication, Computer Communication, Spread Spectrum Techniques, Mobile Communication, Optical communication and networks, Sensor networks, Cyber physical systems, 5G/6G communications, Queueing theory.

Vision and Intelligent Systems (EC5): Computer Vision, Artificial Intelligence, Machine Learning, Computer Networks, Embedded systems, Fuzzy Techniques, Pattern Recognition, Image and Video Processing, Multimedia Coding, Video Transcoding, Multimedia Networking, Video Indexing and Retrieval, Biomedical Image Processing, Deep Learning, Systems Biology, Computational neuroscience, Medical Imaging, Biometric authentication.

2.10 DEPARTMENT OF GEOLOGY AND GEOPHYSICS

Started in 1951, the Department of Geology and Geophysics offers advanced specializations and research opportunities in traditional, modern and applied areas of Earth Sciences. The Department, one of the largest in the country, has a long record of quality teaching and research. Over the years a large number of graduates of this Department have also come to occupy important positions in professional organizations, several universities and research institutes both in India and abroad. The Department has contributed textbooks and reference books to the national and international Earth Science community.

The strength of this Department is primarily its outstanding faculty, an excellent work atmosphere and modern laboratories constantly engaged in quality research activities. At present, a total of TWENTY FIVE LABORATORIES are operational at the Department, that include basic as well as advanced technical facilities: Section Cutting Laboratory; Thin Section Preparation Laboratory; Microscopy Laboratory; Vertebrate Palaeontology Laboratory; Palaeontology Laboratory; Sedimentology Laboratory; Research Microscopy & Microthermometry Laboratory; Fluid Inclusion Microthermometry Laboratory; Stable Isotope Mass Spectrometer Laboratory; Radiogenic Isotope LA-MC-ICP MS Laboratory; SEM Laboratory; EPMA Laboratory; Geochemistry Laboratory; Paleoceanography & Paleoclimatology Laboratory; Laser Raman Microspectrometry Laboratory; Experimental Petrology & Mineral Physics Laboratory; Fabric Analysis Laboratory; Engineering Geology Laboratory; Hydrogeology Laboratory; Remote Sensing & GIS Laboratory; Gravity & Magnetic Laboratory; Computational Laboratory; Advanced Computational Seismology Laboratory; Electrical Electromagnetic Laboratory; Radioactivity & Radon Modelling Laboratory. The Department also houses a Global Broad-Band Seismological Observatory. Apart from these departmental facilities, students have access to other advanced instrumental facilities around the Institute.

In addition to a dynamic and modern course structure (given below), M. Tech. students have ample opportunity to do specialized research projects in a wide variety of disciplines within the Earth Sciences. There are also possibilities of collaborations during project work with other departments in the Institute, and with other Institutes/Universities both in India and abroad. The students also have the opportunity to be part of the Earth Science Study Circle, which promotes both curricular and extra-curricular activities.

GG1 - Exploration Geosciences

Syllabus Details

Hydrocarbon Exploration, Applied Micropaleontology, Basin analysis and Reservoir Characterization, Instrumental Methods in Geosciences, Experimental Techniques in Geosciences Lab, Shallow Surface Geophysics, Advanced Petrology and Geochemistry, Advanced Techniques of Mineral Exploration,

Groundwater Exploration and Management, Remote Sensing and GIS (Theory and Lab), Engineering Properties of Rocks and Soils, Engineering Geology Lab., Geostatistics, Geoinformatics and Data Analysis, Geophysical Exploration Techniques, Digital Signal Processing in Geophysics, Geophysical Tomography, Isotope Geology and Environmental Modeling, Environmental Hydrogeology, Advanced Vertebrate Paleobiology, Marine Geosciences and Paleoclimates, Modern Techniques of Mineral Exploration, Applied Hydrogeology.

Research Areas

Sedimentology; Stable Isotope Geochemistry; Diffusion Chronometry; Micro-, Invertebrate and Vertebrate Paleontology; Accessory Mineral Petrology; Experimental Petrology and Mineral Physics; Metamorphic Petrology; Planetary Geology; Structural Geology and Tectonics; Microtectonics; Engineering Geology and Rock Mechanics; Hydrogeology; Mineral and Groundwater Exploration; Remote sensing and GIS; Seismology; Engineering Seismology; Exploration; Seismic Prospecting; Sequence Stratigraphy; Seismic Microzonation & Risk Evaluation; Electrical & Electromagnetic Geophysics; Geomorphology; Geophysical Optimizations; Gravity and Magnetic Studies; Near-surface Geophysics; Numerical Modelling of Earth Science Problems.

2.11 DEPARTMENT OF INDUSTRIAL & SYSTEMS ENGINEERING

The Department of Industrial and Systems Engineering (ISE) at IIT Kharagpur, formerly known as the Department of Industrial Engineering and Management (IEM), was established in 1973 as Industrial Management Centre and later elevated to a full-fledged department in the year 1983. ISE involves "the design, installation and improvement of integrated systems of people, material, information, equipment and energy by drawing upon specialized knowledge and skills in the mathematical, physical and social sciences, together with the principles and methods of engineering analysis and design to specify, predict, and evaluate the results to be obtained from such systems". (*Womack J T and Jones D T (1996), "Lean Thinking: Banish Waste and Create Wealth in Your Corporation", Simon & Schuster, New York*). Industrial & systems engineers design and improve integrated systems. ISE is a perfect blend of engineering and management science.

The department, in the last five decades, has been instrumental in imparting training and extending frontiers of knowledge in the field of Industrial and Systems Engineering through its well established undergraduate, postgraduate, and PhD programs. These include (i) B.Tech in Industrial Engineering, (ii) Dual Degree - B.Tech. in Industrial Engineering and M.Tech in Industrial Engineering and Management/Artificial Intelligence Machine Learning and Applications/Financial Engineering/Engineering Entrepreneurship, (iii) Dual Degree - B.Tech in Mfg. Science & Engg. And M.Tech in Industrial Engineering and Management, and (iv) M.Tech in Industrial Engineering and Management and (v) M. Tech in Operations Research and Data Analytics. The department is well known across the nation for its excellent teaching, research and consultancy potential in the areas of (i) Logistics and supply chain management, (ii) Optimization and simulation of work systems, (iii) Analytics and data sciences, (iv) Decision support systems, (v) Ergonomics, human factors and safety engineering, (vi) Quality engineering, (vii) E-business, (viii) Product development, (ix) Process excellence, and (x) Healthcare systems. The department is blessed with world class faculty with proven knowledge and expertise in the above-mentioned areas catering to the national needs and requirements in terms of creating quality human resources, and solving industrial, service and management problems.

The students are recruited by core and supporting industries and service organizations such as, Manufacturing/ FMCG consultancies, Analytics firms, IT/ Software services, Financial organizations, etc. The department also provides ample opportunities to the students, both at the undergraduate and post graduate levels, for higher study in world class universities across the world.

The Department offers M. Tech Degree in:

IM - Industrial Engineering and Management

IM1 - Operations Research and Data Analytics (ORDA)

Course Content

IM: For the 2-year MTech Program, the compulsory subjects include (i) Decision Modelling, (ii) Work System Design, (iii) Production Planning and Inventory Control, and (iv) Systems Modelling and Data Analytics. The compulsory laboratories are (i) OR & Analytics laboratory, (ii) Work Design Laboratory, and (iii) Information Systems Project. In addition, each student has to select six elective subjects based on his/her interest and carrier goal from a large pool of electives such as Logistics and Supply Chain Management, Networks and Project Management, Recommender System in E-business, Game Theory and Applications, Quality Engineering, Safety Analytics, Statistical Decision Modelling, Advanced Decision Modelling, Stochastic Modelling of Business, Financial Engineering, Applied Multivariate Statistical Modelling, Logistics Systems and Management, Facility Layout and Design, Engineering Systems Safety Design and Control, etc. After the completion of the two-semester course work, a student carries out a project work leading to a thesis on a live industrial problem. Seminar presentation and group discussions on various topics are some of the regular features of the course.

IM1: The two-year M-Tech in ORDA program, include both theoretical courses for concept development as well as laboratory sessions for hands-on experience in the areas of Operations Research, Machine Learning and Decision Sciences. The compulsory subjects include: i) Applied Multivariate Statistical Modelling, ii) Decision Modelling, iii) Operations Research & Analytics Laboratory, iv) Programming for Data Science Laboratory, v) Advanced Decision Modelling, vi) Machine Learning for Industrial Applications, vii) Machine Learning for Industrial Applications Laboratory. Apart from these, the students have to choose six elective subjects depending on his/her interest from a large pool of industry-relevant courses. These include Financial Engineering, Recommender Systems in E-Business, Software Engineering and Management, Management Information System, Stochastic Modelling of Business, Large Scale Optimization, Linear Algebra for AI and ML, Artificial Intelligence for Manufacturing, Social Computing, Scalable Data Mining, Theory and Applications of Blockchain, Advanced Database Systems, Financial Mathematics, Reliability Analysis and Prediction, Reliability Engineering, Probabilistic Risk Assessment, Production Planning and Inventory Control, Systems Modelling and Data Analytics, Web Data Analytics with Applications, Networks and Project Management, Logistics & Supply Chain Management, Generalized Linear Models and Applications, Quality Engineering, Applied Reinforcement Learning and Optimization, Game Theory and Applications, Safety and Risk Analytics, Deep Learning Foundations and Applications, Cloud Computing, Database Engineering, Big Data Analysis, Multi-Criteria Decision Making, Regression Analysis and Time Series Models, Decision Support Systems, Fault Diagnosis & Predictive Maintenance.

Areas of Research

IM: The thrust research areas of ISE include (i) Logistics and supply chain management, (ii) Optimization and simulation of work systems, (iii) Decision support systems, (iv) Analytics and data sciences, (v) Ergonomics, human factors and safety engineering, (vi) Quality engineering, (vii) E-business, (viii) Product development, (ix) Process excellence, and (x) Healthcare systems. A few key topics of interest includes supply chain optimization, lean & sustainable manufacturing, manufacturing planning and scheduling, management of inventory system, facility location, information system, recommender systems, productivity management, quality control, human digital modelling, safety analytics, system dynamics, project management, healthcare appointment scheduling, patient safety, financial engineering, text analytics, autonomous diagnostics & prognostics, condition-based maintenance, computational intelligence, data mining of complex systems, evolutionary computing, optimisation and simulation, game theory, and business analytics.

IM1: Operations Research Applications (in Healthcare, Disaster Management, Supply Chain Management, Vehicle Routing, Finance etc.), Machine Learning Applications, Safety Engineering and

Analytics, Predictive Analytics, Predictive Maintenance, Systems Modeling and Analytics, Human Machine Interaction, Applications of AI.

2.12 DEPARTMENT OF MATHEMATICS

The Department of Mathematics has started its journey in 1951. During the initial days, the main focus was on strengthening teaching and initiating research groups in various areas of Mathematics and Statistics. However, after few decades, considering the rapid growth of Theoretical Computer Science as an area of Mathematical Sciences, the department started focusing also on Computer Science related subjects and included as part of curriculum in various programs offered by the department. Since the inception, the department had a strong groups in Fluid Mechanics, Mathematical Modeling, Computational Fluid Dynamics, Image Processing and Mathematical Analaysis. Currently, the department has expertise on various areas of Mathematics, Statistics and Theoretical Computer Science. The Department offers a five year integrated M.Sc. course in Mathematics and Computing, a Joint M. Sc-PhD course in Mathematics, and a Joint M. Tech PhD course in Computer Science and Data Processing. The Department also offers Mathematics, Statistics and Computer Science subjects to students of other departments. The department has an excellent computing environment in its own Computer laboratories which are equipped with IBM Power Servers and Dell PowerEdge R710 blade servers for high end computational needs of faculty members and students. Apart from these high end servers the department is equipped with high configuration PCs about 150 in number, ranging from Dell Optiplex 990, Lenovo Thinkcenter Edge, Dell Optiplex 9010, Acer Desktop including high performance i5/ i7 desktops. All these systems are connected to other computing facilities in the Institute through LAN of the institute. For further infor-mation about the department, one may visit its website: http://www.webmath.iitkgp.ernet.in.

The department offers Joint M. Tech-Ph.D program in Computer Science and Data Processing. This program gives an opportunity to students, who have not specialized in Computer Science at degree level but have adequate foundations in Mathematics or Electronics/Electrical/Physics, to specialize in Computer Science. The program aims to produce software professionals who can design and develop systems and applications software, maintain available systems efficiently, and can adapt themselves to research and developments in the rapidly changing field of Computer Science. It is expected that students joining this course should be acquainted with at least one high-level programming language.

MA - Computer Science and Data Processing

Course Content:

Core subjects: Theory and Practice of Programming Languages, Algorithms and Data Structures, Systems Programming, Operating Systems.

Electives: Object-oriented Programming, Discrete Structures in Computer Science, Advanced Numerical Techniques, Theory of Compiler Design, Fuzzy sets and Applications, Software Engineering, Graph Theory and Algorithms, Parallel Algorithms, Formal Languages and Theory of Computation, Mathematical Logic and Logic Programming, Pattern Recognition and Scene Analysis, Queueing Theory in Computer Science, Switching and Automata Theory, Information and Coding Theory, Artificial Intelligence, Advanced Computer Algorithms, Computer Networks, Computer Graphics, Multi-Objective Programming, File Organization and Database Systems, Advanced Techniques in Operations Research, Cryptography and Security Issues, Computational Linear Algebra, Time Series and Forecasting.

The curriculum demands at least six hours of laboratory classes per week in the first two semesters, a seminar in each semester and a comprehensive viva and a two semester project work after the course work.

Areas of Research: Complex Analysis, Functional Analysis, Fluid Mechanics, Computational Fluid Dynamics, Numerical Analysis, Integral Equations, Mathematical Modeling, Operations Research, Data-mining, Image Processing, Queueing Theory, Reliability Theory, Inventory Control, Decision Theory, Fuzzy Mathematics, Graph Theory and Combinatorics, Optimization, Theoretical Computer Science, Cryptography, Information and Coding Theory.

2.13 DEPARTMENT OF MECHANICAL ENGINEERING

The Department is organised into three broad areas of activities as in Manufacturing Science and Engineering, Thermal and Fluids Engineering, Mechanical Systems Design.

M.Tech courses are offered in the above three specializations with wide flexibility in selecting subjects of interest. Research is emphasized at all phases to promote curiosity, creativity and confidence aimed at the intellectual and material advancement of the nation. All twenty three laboratories of the department are well equipped with computational and experimental research facilities in wide ranging fields of mechanical engineering. The Department facilities include computer controlled UTM, hip and knee joint simulators, tribological test rigs, stress analysis test facilities, machinery fault simulator, rotor dynamics test rigs, modal test facility, noise and vibration control facility, digital laser vibrometer, test rigs for evaluation of acoustical materials, robots, robot controllers and flexible manipulators, several high speed data acquisition systems, infrared thermal imaging system, stereoscopic particle image velocimetry (PIV) system, micro PIV system, vibration isolated optical table, low speed wind tunnel, measuring instruments related to flow, pressure and heat transfer, hot wire anemometer, two-phase flow probes, high speed camera system, IC engines performance test rig, gas chromatograph, CAM, instrumented resistance welding machine, synergic MIG welding machine, cutting tool performance test rig, EDM and ECM setup, CNC High Efficiency Deep Grinding (HEDG) system, PVD hard and soft tool coating system, vibration measurement and fault diagnosis, high power fiber laser, pulsed Nd-YAG, excimer and cw CO2 lasers, plasma coating and selective laser sintering machines. There is an excellent central workshop equipped with conventional and modern CNC machine tools. An excellent computing environment has been created with state-of-the-art facilities and related accessories all networked with the institute backbone. Advanced software packages are available in the areas of neural network, CAD, FEM, rigid body dynamics, system modeling, control systems and CFD. In the last few years, the department research and laboratory facilities have been significantly augmented through major sponsored projects and institute funding. The faculty members teaching the courses are actively engaged in research and consultancy in their areas of specialization.

The M.Tech courses offered are:

ME1 - Manufacturing Science and Engineering

ME2 - Thermal and Fluids Engineering

ME3 - Mechanical Systems Design

Course Content:

ME1: The course is a balanced mix of advanced courses in the area of manufacturing processes and systems. Subjects cover areas of Primary manufacturing processes, Machining, Computer control and monitoring of manufacturing system along with electives in Surface engineering, Micro manufacturing, Abrasive machining, Soft computing, Modern manufacturing processes, Welding technology, Metal forming, Manufacturing information system, Laser processing of materials, Rapid prototyping, Intelligent machines and systems, and numerical modeling of manufacturing processes etc.

ME2: Advanced thermodynamics, Heat transfer, Fluid mechanics, Computational methods, Computational Fluid Dynamics, Experimental methods, and a large number of electives from sub-

specialisation areas of thermal science, such as Refrigeration and air-conditioning, Energy conservation, Compressible flows, I.C. Engines, Solar energy technology, Gas turbines and Jet propulsion, micro-fluidics, multiphase flow etc.

ME3: Advanced mechanics of solids, Vibration analysis, Automatic Control, Applied Elasticity, Lubrication and Rotor Dynamics, Experimental stress analysis, Tribology, Mechanics of Composites, Machinery fault diagnosis and signal processing, Acoustics and Noise Control, Engineering Design Optimization, Vibration isolation and control, Continuum mechanics, Robotics and Robot Applications, Human body mechanics, Micro and Nanomechanics, Modern control, Nonlinear vibrations, Fracture mechanics, etc.

Areas of Research: Fluid mechanics, CFD, Two phase flow, Heat transfer, Liquid fuel atomisation and Spray combustion, I.C. engines, Fluidised bed combustion, Refrigeration and air conditioning, Transcritical CO2 based heat pumps, Thermal system modelling and optimization, Solar energy, Optical diagnostics of thermo-fluid systems, Thermal hydraulics of nuclear plants, Micro-fluidics and Micro-scale transport processes, Rheology, Transport processes in nano-fluids and magnetic fluids, Multi sensor measurement and data fusion, Flow of granular material.

Casting, Welding and Metal forming, Machining and grinding, Machine tools, Cutting tools and Coatings, Tool condition monitoring, Thermally sprayed coatings, Electro-physical machining processes, Precision manufacturing, and Laser processing. Computer aided design and manufacture, Computer aided process planning, Rapid prototyping, Intelligent machines and systems, Numerical modeling of manufacturing processes, Modeling and control of microsystems, MEMS.

Vibration based condition monitoring, Automotive Engg., Acoustics and Noise Control, Signal Processing in Mechanical Systems. Systems modeling and design using Bond Graphs, Finite element and Boundary element methods, Computational solid mechanics, Non-linear mechanics, Fracture mechanics, Composite materials, Non-linear elasticity, Smart materials and Structures, Biomechanics, Industrial, bio- and nano-Tribology, Surface engineering. Mechanical systems dynamics, Rotor dynamics, Vehicle dynamics, Bifurcation and Chaos, Fault tolerant control, Machinery Condition Monitoring, Fault Diagnosis and Prognosis.

2.14 DEPARTMENT OF METALLURGICAL & MATERIALS ENGINEERING

The Research and Development Program of the Department encompasses various areas like Extractive Metallurgy, Melting, Casting and Solidification Processing, Powder Metallurgy, thin and thick film processing, Phase transformations and heat-treatment, Mechanical behavior of materials, Corrosion and environmental degradation, Surface Engineering, Modeling and Simulation, development of advanced materials including ultra-high temperature ceramics, nickel based superalloys, titanium aluminides, bulk amorphous alloys, high entropy alloys, and bio-materials. Significant thrust also exists in emerging areas such as development of lithium ion batteries, grain-boundary engineering, etc.

In the field of Extractive Metallurgy significant contributions for metal value extraction, particularly Cu, Ni and Co from sea nodules has been made. Direct reduction of iron ore using mine generated ore and coal fines is another major research area. Understanding CO2 mitigation in steel industry through process models has emerged as a developed area of research.

The major areas in the field of Melting, Casting and Solidification Processing include: development of cast micro-alloyed steels, studies on the hot tearing of long freezing range Al alloys, austempered ductile iron through non-conventional route, grain refinement of Al alloys and the development of cast metal matrix composites. Significant progress has been made in the area of semi-solid processing for casting and mushy-state forming operations of Al-alloy matrix composites. Amorphous and nanocrystalline alloys have been processed by melt-spinning for rapid solidification.

Significant contributions in Powder metallurgy research involves sintering of refractory tungsten based alloys at lower temperatures by using nanometric powders as raw materials, reactive sintering of intermetallic alloys, liquid-phase sintering of alloys and composites, pressure-less sintering of ultra-high temperature ceramic composites, as well as micro-wave sintering, spark-plasma sintering and vacuum hot-pressing of engineering ceramics and composites.

Processing of thin film nanocomposites is carried out by reactive magnetron co-sputtering of high purity elemental targets, followed by characterization of structure and properties. Nanocomposite thin and thick films as well as alloys for various structural and functional applications are also prepared by electro-deposition.

Research involving phase transformations, heat-treatments, and thermo-mechanical processing are aimed at processing micro-alloyed steel, bainitic steels, nickel-based superalloys, and Ti-alloys with desirable microstructures and phase constituents to achieve specified mechanical properties. There is an effort to examine the microstructural evolution along with kinetics of phase transformations. Phase transformations are characterized using differential thermal analyzer, thermogravimetry, differential scanning calorimeter, and dialatometer.

There is a significant interest in study of evolution of microstructure, texture and microtexture, which involve the use of optical, scanning and transmission electron microscopy, X-ray diffraction, electron backscattered diffraction (EBSD) and X-ray Micro-CT. Chemical compositions are analyzed by atomic absorption spectroscopy, energy dispersive X-ray spectroscopy on SEM and TEM, and wavelength dispersive spectroscopy on electron probe microanalyzer. Materials characterization also include use of other sophisticated instruments such as atomic force microscopy, X-ray photoelectron spectropscopy, Auger electron spectroscopy, 3-D non-contact optical surface profilometer, contact type surface profilometer, and nanoindentation.

Mechanical behavior is being examined at different length-scales with objective of relating it to both microstructure and crystallographic orientation. Research involves evaluation of nano-indentation, hardness, tensile and compressive strengths at ambient and high temperatures, flexural strength, creep life (up to 1500 °C) and crack growth behavior, fracture (impact and fracture toughness) as well as fatigue (low cycle and high cycle) properties. Development of newer grades of dual phase and micro alloyed steels has taken place through fracture based studies, correlation between fracture and wear characteristics of materials, development of thin sheet steel components are some important fronts in this direction. In addition, research is progressing in the area of mechanical behaviour of small volume materials, ceramics and composites, as well as Ti-alloys and Ni-based superalloys for high temperature applications.

Mathematical modeling and simulation involves application of molecular dynamics simulations, density functional theory approach, artificial neural networks and genetic algorithm for analyzing and solving various materials related problems. These include diverse topics including mechanical behavior of materials, optimization of metallurgical systems, mathematical simulation of welding, iron and steel making, and other high temperature metallurgical systems by application of computational fluid dynamics, and heat and mass transfer, atomistic simulation of gas hydrates, as well as behaviour of nanostructured materials, Li-ion batteries, etc.

The research activities in the area of **Oxidation and Environmental Degradation** embraces fundamental studies relating to film/scale growth processes on different metal-oxygen and metal-halogen systems with emphasis on kinetics and growth mechanisms, defect structures of compounds, transport properties of different species, adhesion and protective properties of the scales etc. Studies on high temperature oxidation behaviour of multi-phase refractory metal-silicides like Molybdenum and Niobium Silicidesas well as ultra-high temperature ceramics are in progress. In the area of aqueous corrosion, the current activities are concentrated on the studies relating to corrosion or hot corrosion performance of Ni-based superalloys, stainless steels, and Mg alloys.

Significant research is in progress in development of high performance **light metals, alloys** based on titanium, aluminium and magnesium, **and their composites**. Several Al-Cu-TM and Al-TM-Si (TM = transition metal) Al-Ni-Ti ternary alloys, and Al-alloys containing rare earth metals have been synthesized

and characterized to explore the possibility of developing **bulk amorphous** Al-alloy by mechanical alloying and identifying the criteria of selection of such amorphous alloy compositions. In addition, significant progress has been achieved in the synthesis of Fe-TiC, Fe-ZrC and Fe-TiB2 **composites** from cheaper raw materials by aluminothermic reduction method. Development of low temperature copper based composites, steel matrix composites are also prominent areas in the area of composite materials. Activities related to **surface engineering** involves laser assisted surface modification, ion implantation and plasma spray deposition, development of nano-structured coating by electro-deposition.

Development of lead free Sn based solder material, and solid oxide fuel cell are also some areas of active research. In the area of joining research on joining of similar and dissimilar materials using electron beam welding is getting prominence. Development of **Lithium Ion Battery** (LIB) Technology for applications in Electric Vehicles in India has taken the role of a prominent research area in the Department

The Department offers the following specialization:

MT - Metallurgical and Materials Engineering

Course Content:

Core Courses: The Core courses in this programme are thermodynamics of Engineering Materials, Metallurgical Kinetics, Principles and Techniques of Materials Characterization, Programming and Numerical Methods in Materials Engineering, Principles of Materials Engineering (for students with Non-Metallurgy background). A large number of elective courses are also offered, so that the students can specialize in any of the following fields :

Extractive Metallurgy and Modeling, Physical Metallurgy/Materials Engineering, Manufacturing/process Metallurgy, Powder Metallurgy, Corrosion Science and Technology.

Elective Courses: Agglomeration and Direct Reduction of Iron Ores, Rate Phenomena in Metallurgical Processes, Diffusion in Metallurgical Processes, Principles of Materials Engineering, Diffraction Techniques in Materials Engineering, Advanced composite Materials, Interfaces in Nanostructure Thin Film Semiconductors, Ceramics and Refractories : Synthesis, Properties and Applications, Advanced Ceramic Technology, Surface Modification and Coating Technology, Solidification Processing, Processing by powder Metallurgy Techniques, Vacuum Techniques, Advanced Mechanical Behaviour of Materials, Laser Engineering, Computational Fluid Flow, Heat and Mass Transfer in Metallurgical Processes, Surfaces and Interfaces, Grain Boundaries and Interfaces, Dislocation Theory, Mechanical and Thermal Behaviour of Polymers, Crystals Growth and Characterization, Glass Technology, Secondary steel making , Modeling and Simulation of Metallurgical Processes, Fracture Mechanics and Analysis of Engineering Failures, Phase Transformation and phase Equilibria, Heat Treatment Technology, High Temperature Corrosion Biomaterials Advanced Materials and Processes, Thin Film Technology, Amorphous Materials and Applications, Advances in Iron and Steel making , Energetics in Metallurgical Industries, Theory and Practice of Sintering, Advanced Welding Technology, Experimental Stress Analysis, Advances in Mechanical working of Materials, Advanced Electron Microcopy and Analysis, Optoelectronic Materials and Devices, Polymer Reaction Engineering and Reactor Design, Technology of Polymer composite, Magnetism and Magnetic materials, Texture in Materials Engineering, Laser Processing Materials, Imperfections in solids.

These apart, the students can also opt for relevant electives offered by other Department and Centres.

The Laboratory courses include Computer Programming Lab (compulsory), Physical Metallurgy Lab (Compulsory for students with Non-Metallurgy background), Ferrous process Metallurgy and Modeling lab, X-ray and Electron Metallography lab, Phase Transformation Lab, Fracture Mechanics and Analysis of Engineering Failures lab, Materials joining Lab, Powder Metallurgy Lab, and Corrosion and Oxidation lab.

2.15 DEPARTMENT OF MINING ENGINEERING

The Department of Mining Engineering at Indian Institute of Technology Kharagpur was started in 1956, with the approval of the Planning Commission and the All-India Council of Technical Education (AICTE). The first batch of twenty B. Tech students graduated in 1961 and currently the sanctioned strength of the undergraduate program is 81 B. Tech and dual degree students.

The department has introduced a modern Mining Engineering curriculum in India, taking full advantage of the well-developed infrastructure for technical education at the institute. Over the years, the department has offered pioneering subjects of study including rock and geo-mechanics, mineral processing, numerical methods, geo-statistics, GIS & remote sensing, GPS, reliability and quality engineering, safety and occupational health engineering, environmental science and technology, industrial management, operations research, computer programming, data analytics, artificial intelligence techniques and network applications. The faculties are actively involved in sponsored research and industrial consultancy to maintain close relationships with the industry and to develop solutions for industrial problems.

The department has produced a large number of quality textbooks and monographs for mining and allied fields in India. A number of continuing education programs for industry executives and teachers are offered on a regular basis.

Facilities for research have been created over the years in the areas of fire and explosions, subsurface aerodynamics, experimental geo-mechanics, environmental quality assessment, mineral processing and numerical modeling. The tradition of inter-departmental research cooperation at IIT Kharagpur significantly enriches the M. Tech. and Ph.D. programs of the department. This department has awarded more doctoral degrees in mining engineering than any other Institution in India. Quality facilities exist for computer-based investigations, and the students have access to a wide variety of engineering software, testing facilities, and analytical equipment available throughout the institute.

The department will strive to remain in the forefront of science and technology related to mining and natural resources engineering.

Milestones

The department undertook a leadership role in the development of modern and broad-based mining engineering curricula balancing advancement of scientific knowledge and the needs of industries it serves. A two-year interdisciplinary postgraduate program in Mineral Engineering was offered by the department in collaboration with the departments of Chemical Engineering and Geology & Geophysics in 1966. A postgraduate course in Mine Planning and Mechanization was started in 1970 marking it the first full-fledged postgraduate program in the department. Later, an inter- departmental postgraduate program in Mineral Resources Development and Management was also offered.

The department had introduced a dual degree program entitled 'Mine Safety Engineering' in 2004 to develop students with skills to address the challenges of safety in the minerals and allied industries. From Autumn 2019, department offers two new M.Tech Programs in

MI1 - Geomechanics for Mineral and Energy Resources

MI2 - Safety, Health and Environment

MI1 (Geomechanics for Mineral and Energy Resources):
About the Course: The concept of geomechaincs is being applied in excavation of rocks to develop mines, tunnels, caverns and even petroleum fields. Nowadays mining companies like CIL, UCIL, HCL, and others are creating a new position in the field of "Geomechanics" and recruit personnel especially knowledgeable and trained in this field. Minerals and ores are being extracted from deep underground

mines which are subjected to high ground stress conditions. Planning for safe extractions of ores, designing dimension of excavations and monitoring of ground behaviour are the key for success of mining operations. Similarly, large caverns for powerhouse, storage space for LNG, hydroelectric and vehicular tunnels and dams are being built where persons with geomechaincs background are highly required for planning and execution of such large projects. Recent conversation with ONGC reveals that they also require specially trained geomechaincs personnel for their difficult oil and shale reservoirs.

Students from mining, civil and petroleum engineering background will be inducted in this M.Tech program. This program will be a unique post graduate degree in the country for solving multi facet problems of the above industries.

The subjects of this M.Tech program are designed such a way that they cater mining, constructions, tunnelling and petroleum industries. The department feels that this unique and interdisciplinary M.Tech degree in Geomechaincs for Mineral and Energy Resources make the students industry ready as well as prepare them to pursue higher studies.

Areas of Research: Rock Mechanics and Ground Control: Rock fracture mechanics, Slope Stability Analysis, Ground Movement Analysis, Petroleum Geomechanics, Reservoir modelling and simulation, Tunnel design, Design of Tailing Dam, Floor Bearing Capacit, Longwall Ground Control, Reinforcement and Roof Support Design, Drilling and Blasting. Shale gas estimation and simulation of flow; Stability of Large Underground Excavations; Image processing for rock mass characterization; Finite and Discrete Element Methods. Digital Image Correlation, Subsurface Environment: Fluid dynamics and flow through porous media; Mine climate simulation and ventilation; Neural Networks; Fractals and Fuzzy Theory; Genetic Algorithms for Mining Systems; Optimization of Mining Systems.

MI2 (Geomechanics for Mineral and Energy Resources):
About the Course: Environmental clearance for commissioning any industry has been made mandatory. After the operation starts, nearly all major industry has to report to the pollution regulator about the pollutant generated from the operations and the mitigation measures taken. Industrial safety is of utmost importance for success of any industrial operation. Occupational health has been an important subject for a long time, yet there are very few institutes who teach this subject, including IIT Kharagpur. Many industries are now have a full-fledged environmental and safety division who not only takes care of day to day environmental issues related to the operation, but also remain engaged in research to find out better operational protocols for reduced pollutant generation and enhanced safety. Therefore these companies will recruit personnel especially knowledgeable in environment and safety, but the country at present does not produce good number of qualified engineers in this discipline. Therefore an M Tech in Safety, Health and Environment can fill this gap.

Students from mining, civil, chemical, petroleum, mechanical, production and electrical engineering background will be inducted in this M.Tech program because students of these disciplines have some prior background about safety, health and environment (SHE). The subjects of this M.Tech program are decided to cater to mining, petroleum industries, steel plants, thermal power plants and almost all large scale chemical processing plants. This program also provides an opportunity to specialise in SHE areas applicable to oil gas, power, electrical, mechanical, infrastructure and fire and safety. A proficiency in this curriculum will enable the students to work as SHE Engineer, Pollution Control Officers, Environmental Protection Engineer, Consultant in SHE, SHE Audit Officer/Engineer, Researchers in Environment Protection Technologies, and Safety Auditors. The department feels that this unique and interdisciplinary M.Tech degree in Safety, Health and Environment will make the students industry ready as well as prepare them to pursue higher studies.

The course will be offered by Department of Mining Engineering, in association with the relevant departments, namely Civil, Chemical, Electrical, Industrial and Systems, Mechanical, and Petroleum Engineering.

Areas of Research: Reliability, Quality, Safety and Occupational Hazards: Human Behaviour Analysis; Whole body vibration of machine operators, Environmental Pollution Control: Active and Passive

Treatment of Water Pollution; Dust and Hazard Estimation, Noise, Machine vibration, Quality Control and Reliability; Supply Chain Management; Injury Epidemiology Safety Management; Geostatistics. Finite and Discrete Element Methods. Subsurface Environment: Fluid dynamics for shock loss analysis; Mine climate simulation and ventilation. Mine System Engineering: Neural Networks; Fractals and Fuzzy Theory; Genetic Algorithms for Mining Systems; Optimization of Mining Systems; Mine System Design and Mine Machinery Analysis. Mine Planning: Mine Closure Planning; Environmental Policy Studies; Contamination Migration, Clean Coal Technology; Advanced surveying and GPS; Geo-sptial and Geo-imaging; Rescue Robotics, Facility location; Capacity Utilization; Investment and Financing Strategic Planning.

2.16 DEPARTMENT OF OCEAN ENGINEERING & NAVAL ARCHITECTURE

The Department of Ocean Engineering and Naval Architecture set up in 1952 to offer a degree course in Naval Architecture was the first of its kind in India. It started offering a postgraduate diploma in Naval Construction from 1973-74 and a postgraduate diploma in Ship Design and Construction from 1974-75, following a request from the Ministry of Defence, Government of India. The postgraduate diploma was subsequently upgraded to the degree of Master of Technology in Naval Architecture from 1980-81 based on the recommendation of Nayudamma Committee. With the changing scene worldwide, BTech (Hons) is now awarded in 'Ocean Engineering and Naval Architecture' from 1991-92 and M.Tech. in Ocean Engineering and Naval Architecture from 2001-02.

Besides offering the BTech and M.Tech programmes, the Department also offers a five-year dual degree M.Tech programme in Ocean Engineering and Naval Architecture. Research oriented programs leading to MS and Ph.D in the different research areas of the Department are pursued.

The Department is equipped with different laboratories and facilities created over the years and this includes **(a) Ship Hydrodynamics Laboratory** – The laboratory consists of a towing tank 150m long, 4m wide and 2.5m deep and equipped with a towing carriage of maximum speed of 6m/sec. The towing carriage has resistance and propulsion dynamometers with NI based hardware to control the carriage speed and Labview based data acquisition system. A 2D wave maker, single paddle, wetback type with AWACS (Automatic Wave Absorption and Control System) that can generate regular and irregular waves up to 40cm wave height and up to 3 sec wave period is installed at one end of the towing tank. The laboratory has a GPRS linked, Motion Recording Unit (MRU) that can record all 6 DoF. The hydrodynamics laboratory conducts resistance, propulsion and seakeeping experiments for ship models. The laboratory also has a 3-D velocity component measuring unit (acoustic type) for measuring flow dynamics around submerged body /sediment flow. The laboratory has underwater load cells for measuring mooring loads on floating structures **(b) Circulating Water Tunnel** – A circulating water tunnel with a test section of 6m long, 2m wide, 1.5m deep and water speed of 1m/sec with flow control facilities enables studies of flow around floating and submerged bodies as well as measurement of sediment transportation. **(c) Welding and Marine Construction Laboratory** – This laboratory is equipped with various welding units, namely submerged arc welding, shielded metal arc welding, friction stir welding and gas welding. The laboratory also has a set up plate forming using line heating. The welding units have suitable computer support for data acquisition and analysis. Work carried out in this laboratory is in the area of welding simulation, residual stress, weld induced distortion and control. **(d) Structure and Vibration Laboratory** - The laboratory is equipped with a 50kN Universal Testing Machine complete with all accessories to carry out experiments with tensile, compressive and bending loads. The equipment also has a multipoint digital strain data logger. **(e) Model Making Workshop** – To support the experimental activities for the above mentioned laboratories, the Department has a well equipped workshop to fabricate ship models and other accessories for experiments. The models are made of wax, wood, fibre glass, perspex, foam, etc. The Department also has a Computational Hydrodynamics Laboratory (sponsored by Naval Research Board) and a CAD Laboratory. The laboratories of the Department are equipped with various softwares like WAMIT, ORCAFLEX, NAPA, MAXSURF, MULTISURF, SHIPFLOW, CD-ADAPCO, STAAD, ANSYS, Symbols Grapher, Rhinoceros, FLUENT, Midas Civil for structural analysis, Photomodeler for programmatic measurements, ADCIRC, SACS etc. The Department is

continuously upgrading the hardware and software facilities of all the laboratories with state of the art instruments and data acquisition systems.

The Earth Science and Technology Cell (ESTC) is also located in the Department of Ocean Engineering and Naval Architecture. The objective of the Cell, established by the Ministry of Earth Science, Govt. of India, is to promote RD activities in Ocean Science and Technology having societal impact. The cell invites suitable proposals for funding in relevant thrust areas of ocean science and technology. The Department has a "National Programme on Marine Hydrodynamics", sponsored by Naval Research Board, New Delhi, to promote research and development in the area of naval hydrodynamics.

Department offers M.Tech degree in

OE - Ocean Engineering and Naval Architecture

Course Content:
The basic concepts necessary for an appreciation of the field of Ocean Engineering are provided through various core courses such as Analysis of Ocean Structures, Ocean Hydromechanics, Marine Construction and Repair Techniques, Advanced courses in specific area of Ocean Engineering including CAD-CAM in Design and Production, Dynamics of Ocean Vehicles, Computational Methods in Structural Mechanics and Hydromechanics are available in the form of electives. Some of the elective courses offered by the Department are: Ocean Engineering Materials, Dynamical Oceanography, Safety and Marine Pollution, Coastal Engineering, Hydroelasticity, Mechanics of Floating Systems, Ocean Engineering Vehicles and Systems, Powering of Ocean Vehicles, Ship Design, Advanced Ocean Structural Analysis, Computational Methods in Marine Hydrodynamics, CAD-CAM in Marine Design and Production, Port and Harbour Engineering, Ocean Circulation and Wave modeling, Offshore Technology. The courses are so designed that the students from other engineering disciplines can easily adopt themselves to the course curriculum and later specialize themselves in areas like Structural Mechanics, Hydrodynamics, Marine Design and Production and Ocean Technology, Ocean environment. Experimental work in the Department Laboratories also forms a part of the M.Tech programme. M.Tech applicants are required to submit a dissertation, which may be in one of the areas of research in the Department.

Areas of Research: In the last half a century, the Department has made significant contributions to the development of the shipbuilding, shipping, offshore and related industries in the country by providing technical manpower of high quality and by carrying out research and development of international standard. Apart from basic research, the Department is also actively involved in various sponsored research and consultancy projects. The research areas can be classified into the three broad fields as below :

Design and Production: Computer Aided Design and Computer Aided Manufacture, Structural Reliability, Ship Design Optimization, Knowledge Based Systems, Different Welding Methods for Production, Design and analysis of Welded Joints, Methods for Calculation/Estimations of Welding Deformation and Residual Stresses.

Hydrodynamics: Resistance and Propulsion, Computational Fluid Dynamics, Ship Hydrodynamics, Water Wave Mechanics, Coastal Hydrodynamics, Hydroelasticity, Motion of Floating Bodies, Wave loads on Coastal/Offshore Structures.

Structural Engineering: Finite Element Method of structural analysis applied to ship and ocean structures such as stiffened plates, stiffened shells, submerged panels, offshore structures, articulated towers, etc., analysis of the fibre reinforced structures as applied to ocean, aerospace and general engineering systems.

Ocean Environment: Ocean circulation processes and ocean wave modelling.

Placement opportunities: Employment opportunities for Ocean Engineers and Naval Architects exist in various offshore industry, shipbuilding and ship repairing yards, marine classification societies and other government regulatory bodies dealing with marine systems, Navy and Coast Guard, coastal engineering companies, Naval Defense R&D, environmental protection agencies for coastal protection, etc. Being multidisciplinary in nature, students from this program generally receive a broad engineering background, and this helps finding employment in other allied engineering fields as well including management and IT industry. Every year, a section of the students opt to go for higher study in core branches of Ocean Engineering and Naval Architecture and other allied branches of Engineering and Science.

2.17 DEPARTMENT OF PHYSICS

The Department started functioning from the very inception of the Institute in 1951. The areas of research: Astrophysics and Cosmology, Atomic and Molecular Physics, Biophysics, Condensed Matter Physics, Non-linear Dynamics and Hydrodynamics, Nuclear and High-energy Physics, Optics and Photonics, Statistical Physics etc. covering both theoretical and experimental aspects.

The Department offers five years BS-MS and Joint M. Sc.-Ph.D Programme in Physics. It also offers M. Tech. course in:

PH1 - Functional Materials and Devices

Course Content: The prime objective of the course is to educate the post MSc and post B. Tech. students, at advanced level, on such modern areas of functional materials and devices as have developed during the last five decades. The motive is to have an M. Tech. programme which is industry-friendly and effective. Specially trained manpower will be able to solve the newer challenges faced by industries dealing with materials quality and control. This course is getting attention of various industries in the country and abroad. To make the course better balanced and inter-disciplinary, the course curriculum and syllabus have been framed as per the requirements of various stack holders.

The outline of the course content is as follows:

Physics of Functional Materials, Principles of Quantum Devices, Computational Methods for Materials Design, Experimental Techniques for Functional Materials, Magnetic and Superconducting Properties of Solids, Soft Condensed Matter, Physics of Semiconductor Devices, VLSI Technology and Process Modelling, MEMS and Applications, Thin Film Technology, Physics of Surface and Interfaces, Physics and Technology of Optical Fibres, Integrated Optics, Optoelectronics, High Performance Computing and its Applications in Physical Systems, etc. The details of the syllabus and curriculum are available on the institute website.

Areas of Research: The department is actively engaged in both experimental and theoretical research and many of these are of interdisciplinary in nature.

A brief outline of this M. Tech. Programme and research is given below:

The course work of the M. Tech. (FMD) programme of the Department of Physics not only blends physics with applications, but also integrates a scope in computational methods for futuristic materials and device design. Students with the base of physics have good essence of new advances in materials synthesis, and thus in fabricating devices for industrial applications. The one-year experience of project work with internship opportunities make the students well-suited for the 'Research and Development' section of a company.

As a part of the curriculum, the students interact with different departments/centres/schools, like Materials Science Centre, Department of Metallurgical and Materials Engineering, School of Nano Science and Technology, and Advanced Technology Development Centre, of the institute. Students have exposure also in the fields of Artificial Intelligence and Statistical Methods.

The subject 'Physics of Quantum Devices' imparts the knowledge to the students in the field of semiconductor devices, which could be crucial for semiconductor based companies including various semiconducting fabrication laboratories. The trained students through his programme will also be suitable to join the activities under Indian Semiconductor Missions (ISM) recently announced by Government of India.

Along with the core subjects, the structure of the course work provides the students the freedom to select electives from a vast list of subjects floated by the department, as well as by many other departments of the institute. This allows the students to follow their dreams, for example of blending physics with artificial intelligence.

Students engrossed in different programming languages like C, C++, Fortran and MATLAB also can excel in jobs based on programming and computations.

2.18 ADVANCED TECHNOLOGY DEVELOPMENT CENTRE

The Advanced Technology Development Centre (ATDC) was established in July 1998 at IIT Kharagpur. The aim of this centre is to achieve excellence in research using latest technology at the global level and produce trained professional man power for the industry. Advanced Technology Development Centre is an interdisciplinary research centre carrying out research in emerging areas that typically involve researchers from multiple disciplines and niche academic programmes at the postgraduate level. Several stare-of-the-art research units of the Institute carry out research under the academic umbrella of ATDC. They include the Advanced VLSI Design Laboratory, MEMS Design Laboratory, Micro-science Laboratory, Microfluidics, Advanced Laboratory for Plant Genetic Engineering, Communication Empowerment Laboratory, KalpanaChawla Space Technology Cell, Embedded Control Software Laboratory, Centre for Railway Research, etc. A large number of interdisciplinary research projects are carried out under ATDC.

Embedded controls and software,IoT,Micromachining and MEMS and Bio-MEMS are major areas of research at the centre A postgraduate course on embedded controls and software (ECS) is a special initiative that is offered by the centre. Students from various departments like ATDC, Electronics & ECE, Electrical, Computer Science and Engineering, Instrumentation, Mechanical, Chemical, Bio-Technology, School of Medical Science, Civil engineering department, etc. are involved in the interdisciplinary research at the centre. A number of thrust areas have now emerged based on the core competency available in Advanced VLSI laboratory. These include analog and RF circuit, wireless communication and broadband processing, direct conversion receiver, power management circuits, processors and IP cores for embedded applications design for testability. Fifteen leading companies created the AVLSI consortium and collaborative research projects were funded by the government as well as leading companies including National Semiconductor, Intel, Texas Instrument and General Motors etc. During the last few years the MEMS devices developed in the laboratory include silicon piezoresistive accelerometer, quartz based accelerometer, micro-thruster, micro-valve, micro-pump, and flow sensor. MEMS design laboratory, a national facility created under NPSM program, is actively involved with design of MEMS including micro fluidic devices. The Centre offers M. Tech. Program in :

AT1 - Embedded Controls and Software

AT2 - Electric Transportation (Jointly with EE Department)

AT1:

Course Overview: Our world is increasingly becoming automated, through the ubiquitous presence and coordinated involvement of embedded systems, controls and software (ECS). From medical devices to transportation (ships, railways, cars, aerospace, etc.) or security systems to process industries, which affect our daily lives, rapid automation and smart analytics is being incorporated in these systems thanks to the advancement of cyber-physical systems (CPS) along with AL/ML technologies. Further, it is evident that the requirements of the global industry are clearly shifting towards a large demand in advanced and skilled workforce who has the combined expertise related to both CPS hardware and software, resulting in a more complex and multidisciplinary field. This MTech course takes a holistic approach towards developing skilled industry-ready man-power in ECS. It brings together subjects covering diverse ECS components like sensing/actuation, control systems design, embedded communication, CPS resource optimization, reliability and security, AI/ML for ECS, Augmented and virtual reality, signal processing, VLSI CAD, fabrication, integrated optics etc. By taking this course, students from diverse backgrounds such as EE/ECE/IN/CSE can achieve essential trans-disciplinary expertise.

Placement: Due to tremendous interest from the industrial sector, this course has witnessed 100% placement every year in companies like Honeywell Technology Solutions, Mercedes Benz, Eaton Technologies, NetApp, TVS Motors, Intel, Samsung, Google hardware, Mentor Graphics etc.

Course Content:

Core Courses: Embedded Control Systems, Embedded Software Design & Validation, Embedded Sensing, Actuation and Interfacing System, Embedded Communication Networks, Software Design and Validation Laboratory, Embedded Controls Laboratory, Embedded Applications Laboratory, Embedded Communications Laboratory, Seminar.

Elective Courses: Principles of Automotive Dynamics and Control, Security aware CPS and IoT design, AI for CPS, Spoken Language Processing, Digital Signal Processing and Applications, Product Design, Augmented and Virtual Reality, Embedded Machine Learning, Distributed Real-time Systems, Embedded Control of Electrical Drives: Design and Implementation. In addition to the above subjects, a student can take allied courses from other departments/centres/schools.

Areas of Research: Current areas of research related to the Masters' program in ECS at ATDC include Embedded Controls and Software; Automotive Controls, Energy Management and Diagnostics, Sensors and Interfacing Circuits; Energy Harvester; Design and Optimization of Real-time Cyber Physical Systems, Security-aware Design of Cyber Physical Systems as well as IoT devices, VLSI Design and CAD, MEMS and BIO-MEMS. Project Sponsoring Agencies: Research Projects are mostly sponsored by SERB, MeitY, EATON, TATA Motors & MHRD, and DST etc.

AT2 :

Course Overview: With the global trend rapidly turning towards electric transportation mainly due to the environmental concerns, several initiatives from the government and other stake holders have been taken round the world to ensure a smooth transition. This program on electric transportation is to meet the growing demand of this technology and the consequent requirement of skilled manpower. This course is unique in providing the required blend of all aspects on electric transportation and automotive systems in general in order to provide students with a holistic view. The course covers automotive dynamics, advanced drive train control, embedded systems, battery and storage technology, advanced power electronics and intelligent transportation systems in the core with a range of electives from all relevant areas of transportation engineering and management. The students will be trained to prefer industry/entrepreneurship or research depending on their acumen and passion.

Course Content:

Core Subjects:

- Principles of Automotive Dynamics & Control; Automotive Electronics; Battery and Fuel cells; Advanced Motor Drives;Intelligent Transportation Systems.

- Power Electronics Laboratory; Embedded Application Lab; Electric Transportation Systems Design Lab.
- Seminar, Summer Internship, Master's Thesis Project (MTP) - 1, 2 and 3.

Elective Subjects:

- Embedded Control of Electrical Drives: Design & Implementation; Automotive Power Converters; Embedded Control Systems; Automotive Sensors and Instrumentation; Modeling and Simulation of Dynamic Systems; Aircraft Propulsion; Control Theory; Machinery Fault Diagnostics and Signal Processing; Estimation of Signals and Systems; Vibration Analysis; Artificial Intelligence: Foundations and Applications; Transforming Self to Nurture Leadership Traits; Science of Happiness and Well-Being; Production and Operations Management; Business Economics.
- Automotive Control of Aircraft; Mechatronics; Urban Transportation Systems Planning; Reliability Engineering; Ocean Engineering Vehicles and Systems; Advanced Propulsion Systems; Fundamentals of Electronic Packaging; Tribology; Mechanical Drives; Project Engineering and Management; Supply Chain Management; Marketing Research; Leadership; Traffic Engineering.

Areas of Research:

- Energy Management and Thermal Management of EV and HEV
- Vehicle Dynamics, Stability Analysis and Control
- High-Performance Advanced Controller for EV Motors and Converters
- Energy-Efficient, High-Power Density, Reliable EV Converters
- Fault Diagnosis and Fault-Tolerant Control of EV and its Drives
- Battery Management System and Health Monitoring
- Autonomous Electric Vehicle and its Control
- Intelligent Control of EVs and HEVs
- Design and Development of EV Chargers and Charging Infrastructures
- Smart Charging (Vehicle to Grid and Grid to Vehicle Technology)

Possible Invited Lectures from Industry Experts: Several well-knownexperts from industries will be actively engaged in all courses offered. IIT Alumni who are experts in E-Mobility will be an integral part and research collaboration with other institutes will regularly contribute to enhance the spectrum of the course.

Possible Internship and Placement Opportunities: Since there is tremendous demand in the automotive industries related to research/development work in electric vehicles, such M.Tech program will have very good job placements. Students will also will be ready to join Ph.D program at the end of the course to venture into state-of-the-art research innovation in E-Transportation.

2.19 CENTRE FOR OCEANS, RIVERS, ATMOSPHERE & LAND SCIENCES

TThe Centre for Oceans, Rivers, Atmosphere and Land Sciences (CORAL) at Indian Institute of Technology Kharagpur was established in March 2005 for imparting quality teaching and advanced research in the area of Atmospheric and Oceanic Sciences. The vision of the Centre is to become a world class educational and research hub for the development of high-quality trained manpower in research on problems related to Oceanography, River, Atmosphere, Land and Climate for societal applications. The Centre would also serve as a knowledge integrator and scientific innovator towards contributing to

the development of predictive Earth System Science. The important mission of the Centre is to identify and address the challenges of the Earth System Science such as climate changes, ocean state simulation, understanding the predictive skills of tropical cyclones track and intensity, thunderstorms, heat waves, carbon sequestration and climate, marine bio-geo-chemical cycling, coastal hazards and so on. Currently, the Centre is offering a two-year postgraduate program: Master of Technology in Earth System Science and Technology. Meritorious students working in the ongoing projects of the Centre are allowed for MS degree. The Centre also offers PhD program. The Centre is equipped with computing and visualization facilities for understanding and working with numerical models (ROMS: Regional Ocean Modelling System; WRF: Weather Research and Forecasting; Regional Coupled Model WRF-ROMS) and other available datasets. The Centre also use the High-Performance Computing facility of the Institute created by Government of India. The Centre recently developed one world class Marine Bio-Geo-Chemical laboratory for understanding the metal speciation in the marine environment. Furthermore, few faculty members of the Centre also carry out field-based observations and monitor activities outside the institute campus for their individual projects. The faculty members of the Centre have active research collaborations with several prestigious institutions in India and abroad to foster quality education and research in the frontier domains.

The Department offers M.Tech degree in:

CL - Earth System Science and Technology

Course Content: The two-year M.Tech. in Earth System Sciences and Technology is designed to meet the trained manpower in the area of Geophysical Fluid Dynamics (Ocean and Atmospheric) and in-depth knowledge on Computational and Numerical Techniques for Earth System Sciences. The course is divided in four semesters with first two semesters having the course work of theory and laboratory. The third and the fourth semesters are mainly devoted to project work. The program is structured in line with new education policy of India and other M. Tech Programmes of the institute providing ample flexibility to the students to learn depths and widths of subjects of their interest.

The core subjects include *Geophysical Fluid Dynamics, Computational methods for Earth System Science, Application of Numerical Techniques for Earth System Sciences, Ocean and Atmospheric Physics Fundamentals, Simulation Lab for Oceanic Processes. The electives subjects cover a set of vast topics from Ocean Dynamics, Atmospheric Dynamics, Tectonics and Fluvial Dynamics, Planetary and Marine Boundary Layer, Resource Potential Mapping, Tropical Meteorology, Carbon Cycle and Global Climate Change, Climate Risk Adaptation, Mitigation and Policy, Weather Analysis and Prediction, Global Climate System and Cloud-Precipitation Processes, Modelling of Extreme Weather Events, Physics of Atmosphere and Ocean, Modelling of Air-Sea Interactions, Physics of Climate System, Climate Modelling, Remote Sensing Exploration of the Ocean, Global Spectral Modelling of the Atmosphere, Climate Risk Assessment in Agriculture, Agro-meteorology, Marine Biogeochemical Cycling, Coastal Processes and Ecosystem, Fundamentals of Marine Resources and Exploration Techniques, Remote Sensing of Terrestrial Climate Variables and Nature Based Climate Solutions.*

Areas of Research: The Centre is involved in frontier research in oceanographic and atmospheric modelling and their processes studies, forest and land systems as well as cryospheric systems. In oceanography, the areas of present research activities include numerical modelling of Bay of Bengal and Indian Ocean, Internal waves, Indian Ocean water mass characteristics and climate variations. In atmospheric research, the present focus is on the modelling studies of atmospheric rivers, Air-Sea interactions, mesoscale modelling of extreme weather events viz., tropical cyclone, heavy rainfall, and flash floods etc. The areas of specific interest in this direction are mesoscale data assimilation and micro-physical processes. The Centre is also involved in urban boundary layer, regional climate modelling and impact assessment studies. Space based observations, retrievals; validation and assimilation of geophysical parameters of ocean, atmosphere and land are another area of research of the Centre. The centre is also actively involved in development of new methods for estimating biophysical variables useful for carbon estimation and modelling using remotely sensed data. In view of India's active research in Antarctica, the Centre is also focusing on the remote sensing of atmospheric composition, ozone hole,

sea-ice and Southern Ocean in relation to climate change assessment.

2.20 CRYOGENIC ENGINEERING CENTRE

Cryogenic Engineering Centre is the only academic unit in India that is engaged in conducting postgraduate studies in Cryogenic Engineering through its M.Tech., M.S. and Ph.D. programmes. Cryogenic engineering is a multi-disciplinary academic curriculum with inputs from several disciplines, namely, Physics, Mechanical Engineering, Electrical Engineering, Electronics and Instrumentation Engineering and Chemical Engineering and Aerospace Engineering.

The Centre offers M. Tech Degree in:

CR - Cryogenic Engineering

Course content: Introduction to Cryogenics and Superconductivity, Basic Refrigeration Technology, Cryogenic Liquefaction Systems and Cryocoolers, Cryogenic Air Separation, Cryogenic Heat Transfer Devices, Heat and Mass Transfer in Cryogenic Systems, Cryogenic Expansion Devices , Compressors and Pumps for Cryogenic Applications, Storage and Transfer of Cryogens, Vacuum Technology, Matter at Low Temperatures, Safety Issues with Cryogenic Fluids, Superconducting Devices and Applications, Superconducting Technology for Power Applications, Superconducting Magnets – Design and Application, Spintronic Materials and Devices, Cryogenic Process Plants Simulation, Upstream and Downstream LNG Technology, Cryogenic Gas Separation and Purification, Hydrogen Technology, Cryogenic Techniques below 1 K, Cryogenic and Semi-cryogenic Rocket Propulsion, Cryogenic Carbon Capture, Cryogenic Instrumentation, Cryogenics and Superconductivity for Particle Accelerator, and different laboratories like Cryogenic Systems Laboratory, Cryogenic Heat Transfer Laboratory, and Cryophysics and Vacuum Technology Laboratory.

Students also take electives from other Departments/Centres.

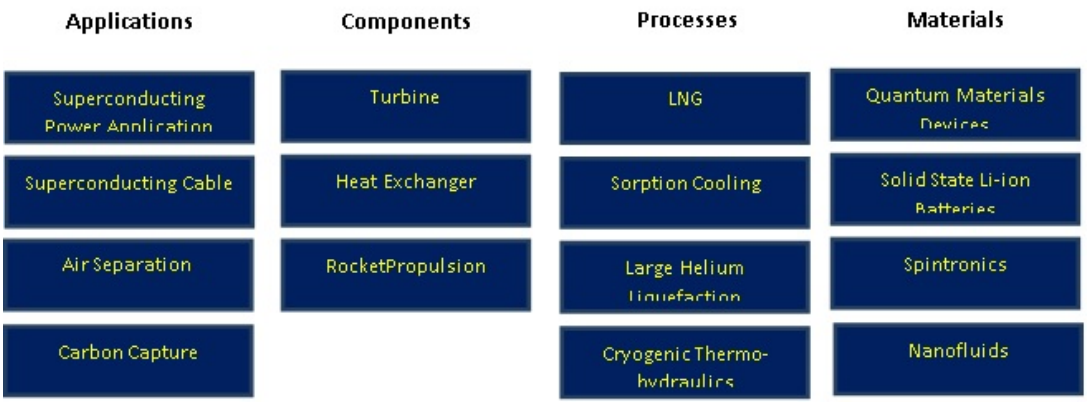


Figure 2.1: Research in Cryogenics

Areas of Research: Major research areas pursued at the Centre include are low temperature physics, quantum materials and devices, applied superconductivity, superconducting magnets, superconducting technology for power applications, thermal & magnetic materials, nanocomposites, sodium ion and thin film batteries, nanofluids, oxygen safety, helium cryogenics, cryogenic heat transfer and fluid flow, cryogenic heat exchangers and rotating machines, cryogenic rocket propulsion, natural gas and hydrogen energy, air separation, carbon capture and sequestration, cryogenic two phase flow, cryogenic energy storage, handling of cryogens for terrestrial/marine/space applications, etc.

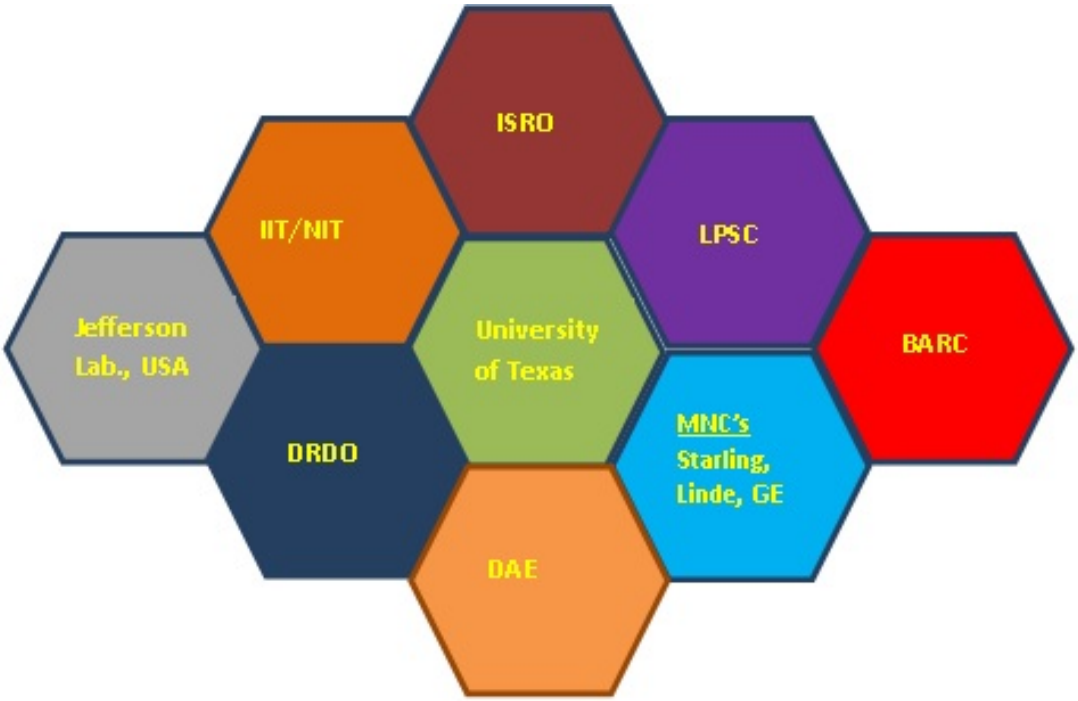


Figure 2.2: Placement of our Distinguished Alumni

Facilities

- LN2 Plant
- LHe (to be added shortly)
- 5T Cryogen free Magnet
- Vacuum Teaching Lab
- Nanoprobe, AFM, MFM, PFM
- Pulsed Laser Deposition
- Vacuum Hot Press 5Ton
- CNC EDM Drilling
- Workshop

Computational resources

- Computation
- Aspen HYSIS
- Labview, Solid works
- Ansys
- Multicore servers

2.21 MATERIALS SCIENCE CENTRE

The Materials Science Centre was established in 1971 to undertake research activities in the areas of glass and ceramics, polymers, semiconductor, allied materials and composites. The development of know-how and manufacturing technologies of many strategic and advanced materials like Opto-electronic Materials and Devices, Semiconductor Lasers, Polymer Blends etc were taken up by the centre. With state-of-the-art infrastructure the centre conducts major sponsored research projects and has developed a range of products today and applications, including Ferromagnetic insulator cermets for Telecom Equipment, Alumina composites, Drag Resistant Polymers for Sprinkler Irrigation Systems, Ceramic Components by Gel Casting, Synthesis of Nano sized Non-oxide Ceramic Powders. Over 200 Ph.D students and 400 M.Tech students have passed out to join academic organizations, industry and research institutions in India and abroad.

The Centre has an active M.Tech Programme in Materials Science since 1980. The annual intake strength is 38 students. The programme is inter-disciplinary and draws on students from physics, chemistry, materials science and engineering, polymer chemistry, etc. The programme is tailored to have mainly core subjects in the 1st semester with more specialized electives in the subsequent semester and a strong component of project work for a year. This is especially useful for the students in generating employment in industry as well as preparing them for a career in research since they get hands-on training on various synthesis/processing tools as well as advanced characterization facilities. The three major emphases of the M. Tech program are: Ceramics, Polymers and Semiconductors.

The Centre also contributes actively to B.Tech programmes by offering courses tailored to the needs of the different Engineering Departments. We also offer a Microspecialization for BTechs in Electronic Materials.

The major research facilities available in the Centre include a Keithley 4200-SCS Parameter Analyzer, Thermal transport measurement facilities (Hot Disk TP2500S), Photoluminescence (PL) unit (PTI USA), Zeiss FESEM, Tescan Vega 2 SEM, Quantachrome BET, Panalytical Empyrean XRD , Class AAA Solar Simulator (Photo Emission Tech, USA), Seebeck Coefficient set up (Advance Riko ZEM-3HR), Cryo-cooled Electrical Probe Station (Janis, USA), Rapid Screening Calorimeter (THT, UK), Zwick UTM, Differential Scanning Calorimeter (TA, USA), Thermogravimetric Analyzer (TA, USA), Perkin Elmer UV-Vis Spectrophotometer, Ferroelectric Loop Tracer (Radiant Technologies, USA), Contact Angle Measurement system, ezHEMS Hall Effect measurement system (Nanomagnetics, UK), Optical Microscope (Leica, Germany), E-beam evaporation system, DC Sputtering system , Spin coater, Dynamic Mechanical analyzer (DMA, Netzsch), Universal Testing Machine (UTM, Zwick), High Temperature Furnaces, CVD systems, Polymer processing and synthesis facilities, etc.

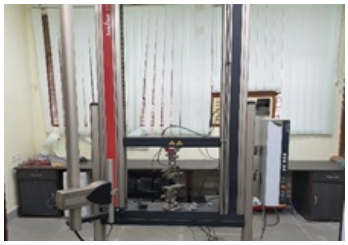
The Centre offers an M. Tech Degree in:

MS - Materials Science and Engineering

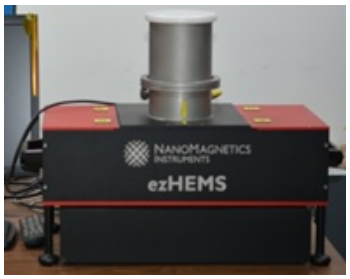
Course Content: The course consists of threee compulsory subjects as an introduction to different types of materials, their preparation, characterization, technology and applications – science and technology of polymers, science and technology of semiconductors, science and technology of ceramics. Additionally, there are two compulsory courses on characterization techniques in the second semester. Students may

Table 2.1: **Major Research Facilities available at Materials Science Centre**

Keithley 4200-SCS Parameter Analyzer

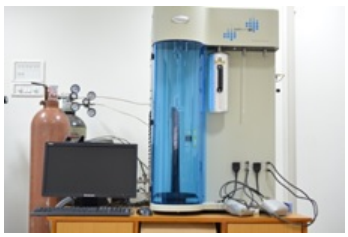


Zwick UTM



Hall measurement

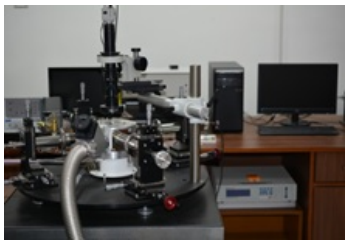
Zeiss FESEM



BET

Panalytical Empyrean XRD

Solar Simulator



Cryo-Cooled Electrical Probe Station

DMA

DSC and TGA

Seebeck Coefficient Measurement

UV-Vis Spectrophotometer

specialize in their chosen areas by taking electives from subjects like: Refractories & thermal barriers, Spectroscopy and structure of glass, Technology of ceramics for electronic applications, Ceramic fabrication & processing, Glass and glass materials, Ceramic synthesis, Solar energy materials, Optoelectronic materials and devices, Semiconductor technology, Introduction to nanotechnology & nano-structured materials, Epitaxy of compound semiconductors, Introduction to biomaterials, Manufacture of industrial polymers, Polymer rheology and mixing, Processing and fabrication of polymers, Technology of polymer composites, Technology of natural and synthetic elastomers, Industrial polymer production technology, Polymer blends and alloys.

The project work is conducted often in collaboration with industry.

Areas of Research:
Nanostructured materials, catalysis, fuel cells, surface, and electrochemistry, refractory materials and coatings for thermal barrier and tribological applications, structural ceramics and porous ceramics, advanced glasses and glass ceramics, bulk amorphous alloys, mesoporous solids, GMR and GMS materials, magnetoelectric materials, structure-property correlations, thermo-mechanical processing and structure evolution, additive manufacturing.

Catalyst free growth of InP quantum dots on Si by MOCVD, low dimensional structures of III-V semiconductors, development of materials for waste heat recovery (thermoelectricity), III-V MOS, embedded ZnO nanostructures in graphene oxide (GO) matrix, functional electro-ceramic materials by soft solution processing, multiferroic ceramics, semi-conducting ceramics for gas sensing applications and intercalating oxides as electrode materials for lithium rechargeable batteries, CVD growth of 2D semiconductor materials, CNTs and Silicon Carbide epilayers, oxide nanostructures and superlattices, superhydrophobic surfaces from inorganic nanostructures, epitaxy of rare earth oxides and Group IV superlattices and interfaces, Physics of low dimensional materials, Nanoelectronics at ultra-low temperatures, Computational Materials Science

Synthesis and characterization of high performance polymers, low dielectric constant polymers, polymers for membrane based application e.g. pervaporation, gas separation and proton exchange membranes, hyperbranched polymers and polymers for electronic applications, polymer blends, reactive compatibilization of multiphase mixtures, polymer-clay nanocomposites, polymer based sensors, polymeric PTCR (positive temperature co-efficient to resistivity) composites, conductive polymer composites, polymeric supercapacitors and EMI shielding materials, LCP based binary and ternary blends, smart polymeric materials, polymeric hydrogels, stimuli responsive and self-healing polymers.

2.22 SUBIR CHOWDHURY SCHOOL OF QUALITY & RELIABILITY

In the present scenario of global competition, Quality and Reliability of products and processes play vital roles in design, maintenance, operational safety/security and management of engineering systems. These are considered as the most pertinent and important performance assessment indices for most of the industrial products, processes and services. Quality and Reliability Engineering is an inter-disciplinary area and plays an important role at different stages of a product life cycle starting from conceptual design to detailed design, manufacturing, operation, maintenance, and disposal. Quality and Reliability Engineering help to improve and designs in best possible ways in terms of operation, safety, easy/faster maintenance, understand the failure process, identify the root causes, suggests better fault diagnosis and maintenance, and quantifies the product performance over a period of its mission life.

Subir Chowdhury School of quality and Reliability is established by rechristening the Reliability Engineering Centre (established in 1983) and named after Mr Subir Chowdhury, Chairman & CEO, ASI consulting group, USA. It is the first and unique School of excellence in India offering Masters' (M. Tech.) and research programs (MS & Ph. D.) in Quality and Reliability Engineering. Apart from these, the School also offers two micro-specializations, viz., micro-specialization in System Reliability Engineering and micro-specialization in Quality Engineering to the UG students.

There is great scope and demand of Quality and Reliability engineers with B.E. / B. Tech. in Mechanical, Electronics, Electrical, Chemical engineering, Computer Science, Production, Manufacturing, and other allied areas. The Students of the School are well-placed in MNC's and reputed organizations, to name few, Alstom, Bridgei2i, BloomEnergy, Cubastion consulting, Cummins India, DRDO, Eaton, Entity Solutions, Faiveley transport, GE, GM, Goodrich, HCL, Honeywell, IBM, Infosys, ISRO, Lam Research, LM Wind Power, Mahindra Tech, NPCIL, Oceaneering India, Philips India, Robert Bosch, TCS, Tata Steel, Time Tooth, TVSE, Vedanta, WIPRO and list continues.

The School has faculty members specialized in the areas of quality and reliability engineering with basic degrees in different engineering branches. The team of faculty members impart the best standard of

education in quality and reliability engineering that is available in our country. In fact, the standard of the M. Tech. course is one of the best in this area and comparable with any international university offering similar specializations. The course curricula of this study are carefully designed to include latest developments, tools, techniques, as well as providing industrial exposure to our students through the internship & exchange programs.

Summarily, the School focuses on overall improvement in engineering skills of students by exposing students to theory and practices in Quality and Reliability Engineering through its academic programs, involving students in research and consultancy projects for Industries and R & D organizations viz., BARC, DRDO, NPCIL, L&T, AERB, Vodaphone, Indian Army, ECIL, ISRO, Crompton & Greaves, Robert Bosch, GE, Covedien, TATA Motors, Secure Meters, Indian Railways, Bosch etc., exposing students to life testing/ prediction/ estimation/ demonstration/maintenance/risk analysis of engineering items, and encouraging them for extracurricular activities as well. All our students are well-placed in various organizations and the feedbacks we receive from them have been very encouraging. The School also conducts short term courses for working professionals in industry and RD organizations regularly, besides, engaging itself in consultancy and research projects sponsored by Industries and Government entities.

RE - Quality and Reliability Engineering

Course Overview: Quality and Reliability Engineering (M. Tech. course) is an interdisciplinary branch of study offered by the Subir Chowdhury School of Quality and Reliability (formerly Reliability Engineering Centre). The School has faculty members specialized in the areas of quality and reliability engineering with basic degrees in different engineering branches. Similarly, our intake students are also from different engineering disciplines. The team of faculty members impart the best standard of education in quality and reliability engineering that is available in our country. In fact, the standard of the M. Tech. course is one of the best in this area and comparable with any international university offering similar specializations. The course curricula of this study are carefully designed to include latest developments, tools, techniques, as well as providing industrial exposure to our students through the internship exchange programs. The School offers post graduate degrees M. Tech., MS and PhD. Short term MDP and EDP courses for working professionals in industry and RD organizations are conducted regularly in various current topics. The School is also actively involved in consultancy and research through projects sponsored by Industries and Government entities.

Please visit here for Curricula and Subjects

2.23 RUBBER TECHNOLOGY CENTRE

In the mid fifties (1955) the Ministry of Education, Govt. of India, decided to establish facilities for promoting rubber technology in the country and established a rubber technology laboratory at IIT Kharagpur in the Department of Applied Chemistry under the aid from Colombo Plan and Technical Collaboration Mission. Subsequently, an independent Rubber Technology Centre was established in the year of 1981 to cater to the need of country's growing technical manpower in the field of rubber technology and allied areas. After its establishment, the centre has earned an excellent reputation of its own for promoting postgraduate teaching and research in different areas of rubber technology. Available facilities include Mixing Mills, Brabender Plasticorders, Press, Rheometer, Plastimeter, Mooney Viscometer, Impact Tester, Hounsfield UTM, Compression Set Apparatus, Dunlop Tripsometer, Abraders, Goodrich and De Mettia Flexometers, Ageing Ovens, Zwick UTM, Thermal Analyzer, Flammability Tester, Monsanto Processability Tester, Dynamic Mechanical Anaylzer, Dielectric Thermal Analyzer, Compression Stress Relaxometer, FTIR Spectrophotometer, Optical Microscope, Brookfield Viscometer, LCR meter and Atomic Force Microscope, RPA. The centre works in close collaboration with other departments/centres of this Institute, Indian rubber industries, Rubber Board and government research establishments. Several research projects sponsored by different agencies like DST, CSIR, DRDO, DAE, BARC, MHRD and industries are in operation. This centre has successfully completed a UK Government collaboration program, and an Indo-UK and an Indo-French collaborative research programmes. The centre is also presently working on industry sponsored projects from India and abroad; for example, with TISCO, NICCO, Phoenix Yule, Goodyear Tire and Rubber Co. USA, EXXON MOBIL Chemical Co., USA, LANXESS, and Germany and so on. The centre has successfully organized three International Conferences so far. There is hundred percent placements every year.

The Centre offers M.Tech degree in:

RT - Rubber Technology

Course Content: Students are taught various aspects of rubber technology i.e. basic rubber science, industrial rubbers, compounding, testing, rheology and processing, rubber products and manufacturing technology, component production and design, latex, tyre technology, adhesion science and technology, engineering design and characterization. In addition to the above-mentioned subjects, the students are allowed to opt for the subjects offered by other departments, i.e. computer software, management, chemical engineering and engineering drawing. The project work is carried out in different rubber and allied industries as well as in several R and D sectors in this country.

Areas of Research: Compounding and vulcanization, Polymer blends and alloys, Rubber based composites, Thermoplastic elastomers, Adhesion science and technology, Electrical and electronic applications of rubbers, Dynamic mechanical and thermal analysis, Failure mechanism, Rheology, Industrial rubber products, Modification of rubbers, Ionomers, Recycling of waste rubbers, Micro cellular rubber, Biomedical applications of rubbers, New techniques of Polymerization, Smart Polymers and polymer nano-composites. Research work in different types of Polymer, Polymer based Composites, nano Composites are also research interest of the Faculty members of the Centre.

2.24 Centre of Excellence in Artificial Intelligence

The Centre of Excellence in Artificial Intelligence (CoEAI), established in 2018, is an educational and research centre of AI and ML innovations at IIT Kharagpur. Building on IIT Kharagpur's three decades of pioneering research, the centre is dedicated to revolutionizing industries and society through AI. We focus on four key areas: groundbreaking research, advanced teaching, collaborative industry projects, and dynamic entrepreneurship. Our mission is to forge a future where AI empowers progress and innovation, shaping leaders and pioneers for a transformative tomorrow.

The centre provides excellent facilities for MTech students. The course work is rigorous. The curriculum includes four core theory courses and three core lab courses to lay strong foundations for the students. There is a wide variety of specialized electives encompassing many areas of Artificial Intelligence and data science. The MTech project requires the student to spend one year on a substantial research topic and often leads to very significant research and development work. There are good opportunities to do collaborative project work with industry. There also exist potential options for summer internships. Students can take admission based on different GATE papers DA, CS, EC, and EE. The details can be accessed here: http://www.ai.iitkgp.ac.in/programs

The Department offers M. Tech Degree in:

AI - Artificial Intelligence

Core Courses:
Theory: Foundations of Machine Learning, Algorithmic and Mathematical Foundations of Artificial Intelligence, Deep Learning Foundations and Applications, Artificial Intelligence Foundations and Applications.
Labs: Machine Learning Laboratory, Data Engineering Laboratory, Deep Learning Laboratory.

Elective Courses (not exhaustive): Linear Algebra for AI/ML, Statistical Foundations of AI/ML, Artificial Intelligence for Manufacturing, Artificial Intelligence for Economics, Graph Machine Learning: Foundations and Applications, Visual Computing with AI/ML, Interpretable Machine Learning, AI/ML for Robot Autonomy, Graphical and Generative Models for Machine Learning, Machine Learning for Earth System Sciences, Big Data Processing, Secure and Dependable AI/ML, Knowledge Modeling and Semantic Web Technologies, Advanced Learning Paradigms in AI, Artificial Intelligence for Cyber-Physical Systems.

Areas of Research: Artificial Intelligence and Machine Learning, Knowledge Representation and Reasoning, Information Retrieval, Robotics, Trustworthy AI, Natural Language Processing, Computer Vision and Image Processing, Complex Networks, Social Computing, Cyber-Physical Systems, Safe Learning.

Possible Internship and Placement Opportunities: Since there is tremendous demand for AI in different application areas such as healthcare, legal, automobile, etc., such M.Tech program will have very good job placements. Students will also be ready to join the Ph.D program at the end of the course to venture into state-of-the-art research innovation in different fields of AI and Machine Learning.

2.25 Centre of Excellence in Safety Engineering and Analytics

The Centre of Excellence in Safety Engineering and Analytics (CoE-SEA) was established in July 2020 at IIT Kharagpur under the Institute of Eminence (IoE) scheme of the Government of India. The CoE-SEA embodies to acts as the hub for teaching, learning and practice, knowledge creation, standardization, repository, and dissemination of knowledge and information covering the broad domain of safety engineering and management, occupational and environmental health, human factors and industrial ergonomics, disaster management, AI and data analytics, and safety economics. The centre offers MTech, MS, PhD and post doctoral programs, both for regular candidates and industry professionals. The centre, in the last three years, has been phenomenal in contributing to research, consultancy, and training in the areas related to safety engineering and analytics. Faculty members from the centre have actively participated in various industrial activities. The centre has received an overwhelming response from various industries across the country for the collaborative research to solve the safety problems at their end. The centre is proud to have outstanding faculty with the required knowledge, skills, expertise, and passion to thrive while solving industrial safety problems. The centre has been working in (faculty and

centre level) collaboration with many world leading universities such as (i) University of Purdue, USA, (ii) Texas A&M University, USA, (iii) Technical University Delft, The Netherlands, (iv) Luleå University of Technology, Sweden, (v) Norwegian University of Science and Technology, Trondheim, Norway, (vi) University of Cyprus, and (vii) University of Bologna, Italy. The centre has also been working with world renowned industries such as Tata Steel Limited, Adani Group, and Halida Petrochemicals Limited, and with government agencies such as DRDO, DST, and MoE/MoS/MoD/MSDE.

The details can be accessed here: http://www.coesea.iitkgp.ac.in/

The Department offers M. Tech Degree in:

SE - Safety Engineering and Analytics

The M.Tech program in Safety Engineering and Analytics aims to produce qualified human resources equipped with engineering, analytical, managerial, and leadership abilities. The objective of the program is to impart students with a holistic view of Safety Engineering and Analytics across an organization through engineering approaches, use of technologies, advanced analytics and managerial insights. It offers a pathway to diverse, high-demand safety, occupational health and analytics careers. The interdisciplinary program is developed to benefit students from both academic and professional backgrounds. The students will be highly suitable for the engineering, management and strategic positions of organizations in the areas of safety, risk, occupational health, resiliency, and sustainability. Potential recruiters for students would be from various sectors such as nuclear & fuel, transportation and logistics, mining, metallurgical, oil, gas, and chemical industries, infrastructure and construction sectors, manufacturing industries such as automobile, locomotives, and white goods, extended reality (XR) sector, disaster management, risk, insurance & sustainability, healthcare industries, research and development laboratories such as DRDO, ISRO, BARC, Indian Armed Forces, etc.

Course Content: The 2-year MTech program comprises compulsory theory and laboratory courses, seminar, summer internship, and project work. In the first year (first and second semesters), all the theory and laboratory courses along with an initial project (project 1) will be completed. In the second year (third and fourth semesters), students will undergo through internship and two semester-wide long projects (project 2 in semester 3 and project 3 in semester 4), which can be conducted in the industry or in academia, as part of their MTech thesis projects. Industry-oriented projects are encouraged. The compulsory depth subjects include (i) Process Safety Engineering (ii) Human Factors Engineering (iii) Occupational Safety Engineering (iv) Safety and Risk Analytics. The compulsory laboratories are (i) Safety Engineering Laboratory (ii) Work System Design and Virtual Reality Laboratory (iii) Safety and Risk Analytics Laboratory. The electives span over four distinct domains such as Safety and Occupational Health, Reliability and Quality, Data Analytics, Management and Leadership. The electives include Safety Economics, Industrial Hygiene, Industrial Pollution Control, Hazardous Waste Treatment and Management, Safety Legislation and Environmental Law, Disaster Management, Environmental Impact Assessment, Road Safety and Management, Reliability Engineering, Statistical Methods in Reliability, Maintenance Engineering, Quality Engineering, Reliability Design, Six Sigma Fundamentals and Applications, Fault Diagnosis and Predictive Maintenance, Applied Multivariate Statistical Modeling, Generalized Linear Models with Applications, Machine Learning, Natural Language Processing, Decision Modelling, Deep Learning Foundations and Applications, Dependable and Secure AI-ML, Web data analytics with applications, Business Economics, Human Resource Systems, Project Engineering and Management, Total Quality Management, Techno Entrepreneurial Leadership, etc.

Areas of Research: Integrated Safety Management, Process Safety Management, Hazard Identification and Risk Assessment, Safety Analytics, Industrial Safety, Occupational Safety and Health, Nuclear Fuel Cycle Facility Safety, Space Safety, Mine Safety, Transportation and Logistics Safety, Fire Safety, Oil, Gas and Chemical Safety, Construction Safety, MSME Safety, Electrical Safety, Manufacturing Safety, Marine Safety, Aviation Safety, Cyber Physical Systems Safety and Security, Virtual and Augmented Reality, Artificial Intelligence, Machine Learning, Predictive Data Analytics, Decision modeling and Optimization, Risk and Uncertainty Analysis, Situational Awareness and Human Sensing Technologies, Behavior Based Safety, Human Factors and Ergonomics, Operations Safety Economics, Prevention through Design (PtD), IoT based Smart Safety, Reliability, Preventive and Predictive Maintenance, Fault Diagnosis and Prognosis, Intelligent Asset Maintenance, Injury Epidemiology, Injury Prevention, Occupational Diseases, Job Stress, Noise, and Hearing Loss, Risk, Resilience and Sustainability, Digital Human Modeling, and Human-Centric Design and User Experience.

2.26 G. S. SANYAL SCHOOL OF TELECOMMUNICATIONS

Named after late Prof. G. S. Sanyal, former Director of IIT Kharagpur, G. S. Sanyal School of Telecommunications (GSSST) was set up on November 8, 1996. Mrs. Kiran Malhotra and Mr. Arjun Malhotra had the vision on growth potential and relevance of ICT in India. An invaluable endowment from them helped setting up GSSST to function as a centre of excellence in the area of Telecommunications Engineering. The School should fulfil the needs of education, research, technology development and training in broad areas related to telecommunications engineering.

The School has been offering PhD, MS (by research) and MTech programs. The GSSST research group includes an impressive number of MS and PhD scholars engaged in various contemporary and futuristic problems, primarily in the areas of wireless communications, signal processing and networks. The School is actively engaged in collaborative research with several international and national research organizations and private telecommunication industries. Multiple funded research projects are also under execution. Being a research school the MTech students are exposed to contemporary research problems of communication which helps them to become industry ready and competent enough to do further studies.

G. S. Sanyal School of Telecommunications announces call for admission to its M.Tech. Program on 'Wireless Communications and Networks' for the academic session 2023-2024.

GS - Wireless Communications and Networks

Course Content:

Core Subjects: Communications Signal Processing and Algorithms; Broadband Access Networks; Telecommunications Network Planning and Management; MIMO Communications.

Electives: The students will be able to choose elective subjects that may be offered from the GS Sanyal School of Telecommunications and other sister departments of the Institute.

Electives from the School: Teletraffic Engineering; Spread Spectrum Communications and Jamming; Telecommunication Networks and Optimizations; Telecommunications Network Security; Communication Services and Applications; Emerging Topics in Communications Engineering – I; Emerging Topics in Communications Engineering – II; Network Information Theory.

Electives from sister departments of the Institute: Information Theory and Coding Techniques; VLSI for Telecommunications; Embedded Systems; Digital Signal Processing and Applications; Wireless Adhoc and Sensor Networks; Quantum Computing and Quantum Information Processing; Lightwave Networks; Mobile Communications and Fading; Software Engineering; Distributed Systems; RF and Microwave Integrated Circuits; Parallel and Distributed Processing; Information and System Security.

In addition to the above, a student may also opt for other PG level subjects as permissible.

Lectures will be augmented by well-designed experiments in Communications Hardware Laboratory, Communications Simulation Laboratory and Embedded Communications Laboratory.

Current Areas of Research Interest:

Wireless Communications and Networking: (i) Cellular Networks, (ii) Broadband Wireless Access, (iii) Wireless Sensor Networks, (iv) Radio Technology Design for 5G Cellular, (v) Satellite Communication Systems, (vi) Under-water Communication Systems, (vii) UWB, 60 GHz Communication, (viii) Wireless Local Area Networks, (ix) Signal detection and estimation, (x) Green Radio, (xi) Cognitive Radio Networks, (xii) Biomedical signal processing, (xiii) Physical Layer Security, (xiv) Visual Light Communications, (xv) Quantum Communication, (xvi) Neural Information Processing. (xvii) Millimeter Wave Communication and Terahertz Communication, (xviii) Virtualization of Network Functions (xix) Edge Computing (xx) Software Defined Networks (SDN) (xxi) IoT and Wireless Communication for Persons with Disabilities (xxii) Vehicular Networks (xxiii) Inter Planetary networks.

Optical Communications and Networking: (i) Optical Access Networks, (ii) Optical switching, (iii) In-home network architectures, (iv) Fibre-coax solutions, (v) Optical Network-on-Chip, (vi) Coherent Optical Communications, (vii) Optical Backbone Networks, (viii) Elastic Optical Networks (EON), (ix) Gigabit Passive Optical Networks (GPON).

Artificial Intelligence and Machine Learning: (i) Machine learning on graphs or networks, (ii) Automated answer grading, (iii) Artificial intelligence for digital library, (iv) Machine Learning Models and Fundamentals, (v) Big Data processing (vi) Natural Language Processing.

2.27 RANBIR & CHITRA GUPTA SCHOOL OF INFRASTRUCTURE DESIGN & MANAGEMENT

The mission of Ranbir and Chitra Gupta School of Infrastructure Design and Management is to develop outstanding professionals capable of designing and delivering quality infrastructure projects efficiently and effectively with a comprehensive and fast-track approach to complement the Government and the Industry in shaping country's Infrastructural development through state-of-the-art knowledge base, research, consultancy and active collaboration.

The school offers a MTech programme on Infrastructure Design and Management which aims at a multi-disciplinary approach to handle the issues of the infrastructure sector. The course is more focused towards the system approach rather than the statutory individualistic outlook.

The Department offers M.Tech degree in:

ID - Infrastructure Design and Management

The M.Tech programme has been designed with focus on planning, management, and effective delivery of large robust infrastructure projects in areas such as Transportation, Power, Utility Infrastructures and infrastructure facilities. The programme is multi-disciplinary in nature. Faculty members of different departments, schools and centers participate in the teaching and research activities of this programme.

Students joining this programme will have the option of selecting courses in such a way as to gain expertise relevant to the infrastructure sector of their interest.

The programme is currently designed for graduates in architecture, civil engineering, electrical engineering and mechanical engineering.

The programme has five theory subjects and three laboratories as core (compulsory) courses and five elective subjects, to be covered in the first year. The elective subjects are being so grouped (the groups being designated as verticals) as to enable the students to select appropriate electives depending on their background and interest.

Course Content: The five core subjects And three laboratory components to be covered by all the students are Project Engineering and management, Financing Infrastructure Projects, Infrastructure Regulatory Issues, Quantitative Methods for Decision Making, Environmental Impact Assessment, Simulation Laboratory, Virtual Reality Laboratory, Project Management laboratory.

The elective courses have been grouped under the following four vertical groups:

Transportation: Urban Transportation Systems Planning, Airport Planning and Design, Bridges and Tunnels Engineering, Analysis and Design of Pavements, Traffic Engineering, Analysis and Evaluation of Transportation systems, Highway Construction Practice, Planning, Operation and Management of Transportation Facilities, Sea and Inland Port Infrastructure.

Public Utilities: Water Supply Systems, Waste Water Management, Solid Waste Management, Air Quality Management, Environmental Sanitation, Hazardous Waste Management,

Facilities Infrastructure: Transportation Planning and Traffic Engineering, Housing Infrastructure, Facility Programming and Specialized Building Design, Building Management Systems, Regional Infrastructure Development, Environmental Planning, Remote Sensing and DIS in Planning.

Power Systems: Thermal, Hydel and Nuclear Power Generation, Power Infrastructure : Generation, Transmission and Distribution, Internal Combustion Engine, Power Transmission Systems, Non-conventional Electrical Energy Systems, High Voltage and Insulation Engineering, Power Infrastructure : Economics, Management and Environment, Power System Planning and Reliability, Air-conditioning and Ventilation, Power Systems Transients and Protection, Opto-electronics based instrumentation, AI applications to Power Systems.

The details of the syllabus and curriculum are available on institute website.

Areas of Research: Project management, infrastructure financing, Infrastructure planning and systems management, housing and community planning, Planning and management of rural an urban transport systems, pavement and airport management systems, environmental impact assessment, system analysis and water quality management, process modification and pollution minimization, environmental life cycle assessment, power system analysis and operation, non-conventional energy sources, power system planning and reliability.

2.28 SCHOOL OF ENERGY SCIENCE AND ENGINEERING

School of Energy Science and Engineering (SES&E) started in 2013 is an inter-disciplinary program at IIT-Kharagpur. This School provides critical research inputs in all aspects of energy science and Engineering. SES&E also provides research leadership at the national and international level by offering an interdisciplinary research forum and academic program for the study of energy systems, which emphasizes on technology demonstration and collaboration in harnessing Renewable Green Energy resources. This School initiated Ph. D. programs in Energy Science and Engineering (from Autumn 2014-15) and a two-year M. Tech. program in Energy Science and Engineering (from Autumn 2015-16). Plans are on the anvil to offer MS by research and dual degree courses in future. These programs are intended to provide the students with a comprehensive exposure in energy science and engineering right from natural

resources, material development, modeling, system development and application to integrate with existing grids in delivery of electricity a clean form of energy – greatest gift of science to humanity.

This school conducts and supports research activities with multidisciplinary inputs from several departments/centers such as Electrical Engineering, Mechanical Engineering, Chemical Engineering, Biotechnology, Agriculture and Food Engineering, Physics, Chemistry, Metallurgical & Materials Engineering, Materials Science, School of Management and School of Intellectual Property law.

ES - Renewable Energy Technologies

Course Overview : Rapid development of renewable energy technologies is of critical importance for environmental sustainability and economic growth of the world. Throughout the world there is tremendous research and industrial development activities undertaken to transition to a low carbon economy using renewable resources. This programme is offered to meet the growing demand for technical manpower in these areas. The courses in the programme are designed to build technical knowledge competence in the related scientific fundamentals as well as engineering techniques for conversion, storage and management of energy. The course covers the major renewable technologies such as solar, wind, biomass and hydro energy resources and technologies as well as battery storage and fuel cells. Laboratory courses offer experimental exposure to the theory subjects. Students can customise their areas of expertise through choice of electives and project. Students can also choose from the pathways of Professional Practice or Research and Innovation depending on their interest. Graduates of this programme are expected to be well received in organisations related to energy storage, electric mobility, solar photovoltaics etc.

Course Contents

Core Subjects:

- Bioenergy Resources and Technologies; Battery Storage and Fuel Cell; Wind and Small-Hydro Technology; Solar Photovoltaic Technologies and Systems.
- Renewable Energy Systems Laboratory; Energy Systems Design Laboratory.
- Seminar, 8 week Internship, 3 semester Master's Thesis Project.

Elective Subjects:

- Energy Materials; Energy: Policy and Governance; Power Systems Analysis and Operation; Characterization and Analysis of Biomass and Biofuel; Power Electronic Converters and Machine Drives; Computational Methods in Thermal Engineering; Physics of Functional Materials; Electro Analysis and Sensors.
- Solar Thermal Energy Systems; Metabolic Systems Biology for Biofuels; Energy Systems Modelling; Waste To Wealth: Microbial Intervention; Air Conditioning and Ventilation; Gas Turbines and Jet Propulsion; Energy Economics; Physics of Renewable Energy Systems; Energy Storage Technologies

Areas of Research:

- Solar PV: Hybrid Generation, Flexible Solar Cells and Applications
- LIB Energy Storage: Modelling and simulation, Fabrication of cells, BMS and Charging.
- Thermo-fluidics: Surface guided fluidics, Electronic cooling, Thermal storage
- Bio-Energy: Microbial Fuel Cell, Metabolic Engineering of yeast, Algae and cyanobacteria for biofuels
- Microgrids: AC/DC Microgrids, Resilient Reconfigurable Microgrids, Building Microgrid

Industry Inputs:
Experts from industries can participate in the courses as lecturers. They can also participate a project or internship mentors. There are also opportunities through interactions in the context of sponsored research projects in which students can participate.

Internship and Placement Opportunities:
In view of the growth in interest in renewable energy technology industry, the graduates of the program are expected to have attractive opportunities for placement. Students will also have good opportunities for a research career. It is also possible to participate in entrepreneurial business ventures which are rapidly growing in renewable energy technologies.

2.29 SCHOOL OF MEDICAL SCIENCE AND TECHNOLOGY

Innovations in Technology have led to spectacular advancements in modern medicine. To meet the challenges, there is a need to bridge the two disciplines by fusion of medical science with technology. With this philosophy in mind, Indian Institute of Technology, Kharagpur established the School of Medical Science and Technology with the objective to provide a platform of interdisciplinary teaching and research in diverse areas of medical science and technology. The school provides an excellent inter-disciplinary platform to interact and work together towards the enrichment of basic & medical sciences, and advanced healthcare delivery system to serve people. The school collaborates with some of the best medical research institutes and industries from India and abroad.

Apart from the existing three years interdisciplinary Master's Program in Medical Science and Technology (MMST) for medical doctors and MS and PhD programs in Medical Science and Technology, the School has introduced **M.Tech program in Medical Imaging and informatics from Autumn 2008-09 and the school has also recently introduced another course with specialization in Biomedical Engineering**. The objective of this programme is to educate students and researchers on engineering principles for the analysis and manipulation of biological systems, working at the interface between engineering and life sciences. The eventual aim is to develop novel approaches in biomedical technology with applications to medicine and biology. The programme will facilitate multidisciplinary and interdisciplinary approaches in biomedical research, towards creating a centre of excellence in training and research for a new generation of students. This program will bridge the gap between medicine, biological sciences and engineering with a roadmap to develop world-class scientists aiming to invent new technologies, to solve outstanding problems in medicine and human health, and developing deeper understanding of the "intelligence" of living systems.

The M Tech students will be exposed to different aspects of translational health research which will include medical imaging and advanced image processing systems, biomedical signal processing BioMEMS and sensors, Biomedical Instrumentation, Embedded systems, Microfluidics and point-of-care diagnostics, Biostatistics, Biomaterials, Regenerative Medicine, Cancer research, Cardiovascular research, Immunology and Immunotherapeutics, Biomarker Discovery, Herbal medicine, Clinical and Epidemiological research and Molecular virology research.

The students will have access to some of the finest infrastructure available in the country for interdisciplinary research and development activities, some of which are:

Automated ECG and 12-channel EEG; PC based Spiro meter, Electronic stethoscope and Phonocardiogram; DSP trainer kit with FPGA; Electro-Acoustic Transducers; a multi-channel bio-signal amplifier

with 144 channels for invasive and non-invasive measurements of the brain that is FDA cleared and CE approved, Myograph, Ultrasonogram and Color Doppler, Ultra sound scanner, Digital Radiography, Analog X-Ray Machine; OCT, Live cell imaging and Apotome, Stereo-zoom microscope, Atomic Force Microscope, Micro-CT, A 2-port handheld VNA capable of S-parameter, magnitude, phase, and time-domain, spectrum analyzer.

DNA finger printing; Southern and Western blotting apparatus; RT-PCR; Dark/cold room/(-150°C); Software for protein analysis (RASMOL, RASWIN); ELISA reader, Scintillation counter; MALDI-ToF Mass Spectrometry; Fluorescence Activated Cell Sorter(FACS), AFM, 2-D Gel, Magnetic Cell Sorter, FTIR Microscopy Imaging System.

Surface tension and contact angle measuring device; Universal Testing Machine; FT-IR and UV spectrophotometer, 3-D Laser-scanner, Electro-spinning, Rheometer, CMC Machine, Cell Culture, RT-PCR, microfabrication facility.

Server and terminals; Video conferencing unit; PACS System, Telemedicine software supporting live medical tele-consultation.

It is expected that M.Tech students will get job opportunities in the corporate and government organisations in the field of medical engineering and technology. They will also have good prospects to pursue research in the frontiers of biomedical engineering & sciences in India and abroad.

The School offers M.Tech degree(s) in:

SM - Biomedical Engineering

SM1 - Medical Imaging and Informatics

The M.Tech., program in Medical Imaging and Informatics is offered jointly with the department of Electrical Engineering. SM1 (Biomedical Engineering)

Course Content: Course Content: Coursework covering different aspects of medical technology and research and includes six core and seven elective subjects that will help students to understand the fundamentals of living systems

Core Subject: Basic Human Anatomy, Physiology, and Pathology-Theory & Lab, Mathematical Methods in Biomedical Engineering, Experimental Methods in Biomedical Engineering, Thermodynamics and Transport in Biological Systems, Medical Imaging Laboratory, Seminar-I, Seminar-II. 2-semester project thesis.

Elective Subjects: Biomedical image processing and interpretation, Medical biotechnology, Biostatistics, Physics and instrumentation of medical imaging, Fundamentals of biomaterials and living matter, Statistical physics in biology, Proteomics and metabolomics in health and diseases, Biological physics, Animal transgenic technologies, Evidence based medicine, Digital image processing and applications, Computational structural biology, Digital signal processing, Fuzzy sets & applications, Digital image processing and applications, Algorithms for bioinformatics, Computational neuroscience, Computational methods and algorithms in signal processing, Systems biology: modeling and control, Biomicrofluidics and BioMEMS, Computational methods in biomedical engineering, Introduction to biomechanics of solids, Biomaterials: tissue interactions, Molecular principles of biomaterials, Ethics in biomedical research, Physiological systems and analysis, Cancer biology, Stem cell biology and therapy, Pattern recognition and machine intelligence in medicine, Advanced immunology and immunotherapeutics, Computational biophysics: algorithms to applications, computational phylogenetics and molecular evolution, Biomedical signal processing, Medical image analysis, Digital image processing, Biomedical system engineering and automation, Evidence based medicine-II.

Areas of Research: Medical Imaging & Image Analysis; Rehabilitation Engineering; Cancer Research, Biomedical sensors & Instrumentation; Regenerative Medicine, Preventive & Promotive Healthcare System; Bio-markers & their application in Oncology; Wound Healing Research & Tissue Engineering; Biomaterials; Microfluidics & Point of care diagnostics, Bio-MEMS & Sensors, Prosthesis, Orthosis & Implant Design, Reproductive Biology, Herbal medicine, Immunology & immunotherapeutics, Cardiovascular Research, Healthcare Information Management System; Biostatistics.

SM2 (Medical Imaging and Informatics)

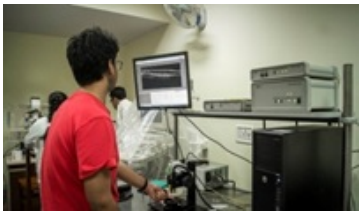
Course Content:

Core Subject: Digital Image Processing and Applications, Basic Human Anatomy, Physiology, and Pathology, Imaging & Image Processing System Design Laboratory, Physics and Instrumentation of Medical Imaging, Seminar-I, Medical Imaging Informatics, Pattern recognition and machine intelligence in Medicine, Medical Image Analysis, Medical Image Analysis & Informatics Laboratory, Telemedicine Laboratory, Seminar-II.

Elective Subjects: MEMS and Biosensors, Biostatistics, Biomedical Instrumentation, Digital Signal Processing, Fuzzy Sets & Applications, Telemedicine, Molecular Imaging, Nuclear Imaging, Biomedical System Engineering & Automation, Pathological Image Processing, Computer Vision, Internet & Web based Technologies, Biomedical Signal Processing, Application of machine Learning in Biological Systems, Nano-biotechnology enabled point of care, bio-microfluidics and Biomems, Biomedical Devices.

Areas of Research: Medical Imaging and Image Analysis; Rehabilitation Engineering; Biomedical sensors and Instrumentation; Healthcare Information Management System; Telemedicine; Preventive and Promotive Healthcare System; Bio-markers and their application in Oncology; Tissue Engineering; Biomaterials; Nano-technology and MEMS in Medicine; Prosthesis, Orthosis and Implant Design. Reproductive Biology.

Table 2.2: **Research Facilities available at School of Medical Science & Technology**



2.30 SCHOOL OF WATER RESOURCES

The School of Water Resources at IIT Kharagpur is one of the pioneer centres for education, research, training and consulting solutions in water quality and quantity management. It aims at providing integrated and interdisciplinary approaches involving hydrological, environmental, chemical, biophysical, economic, institutional, and policy-planning aspects, to solve the ever-growing water-related challenges in domestic, agriculture and industry sectors. It aims to develop knowledge, insight and engineering skills required to design, implement and evaluate water management policies and strategies. It also intends to establish a participatory relationship with industries, Centre and State governments, and academic institutes in order to produce skilled water engineers and managers.

The school offers interdisciplinary M.Tech. (Water Engineering and Management) and Ph.D. programmes to the students, professionals and researchers from the disciplines of Civil Engineering, Agricultural Engineering, Chemical Engineering, Environmental Engineering, Water Resources Engineering, Irrigation and Water Management, Infrastructure Engineering, Civil Engineering and Planning.

The school is involved in interdisciplinary research with the focused thrust areas of urban water management (Water distribution, Wastewater treatment, disposal and recycling, urban flooding and its management); Water economics and pricing; Surface water – groundwater – seawater interaction; Impact of anthropogenic activities and possible climate change on water resources; Water quality management at river basin and urban scales; Hydroinformatics in urban water supply, waste water disposal and real-time flood management.

The school offers M.Tech Degree in:

WM - Water Engineering and Management

Course Structure:

Semester - I			
Name of the subject	Subject type	L-T-P	Credits
Environmental Hydrology & Hydraulics (WM60007)	Theory Core – 1	4-0-0	4
Sectoral Water Demand and Distribution (WM60011)	Theory Core – 2	4-0-0	4
Planning and Design of Water Engineering Facilities (WM69007)	Lab Core – 1 (Design Lab)	0-0-3	2
Geo informatics laboratory (WM69005)	Lab Core – 2	0-0-3	2
List Annexed	Elective – 1 (Depth)	3-0-0	3
List Annexed	Elective – 2 (Breadth)	3-0-0	3
Seminar	Core	0-0-3	2
	Total		**20**

Semester - II			
Name of the subject	Subject type	L-T-P	Credits
River Basin Planning and Management (WM61002)	Theory Core – 3	3-1-0	4
Water Engineering Laboratory (WM69006)	Lab Core – 1	0-0-3	2
List Annexed	Elective – 3 (Depth)	3-0-0	3
List Annexed	Elective – 4 (Depth)	3-0-0	3
List Annexed	Elective – 5 (Breadth)	3-0-0	3
Project (MTP-1)	Core	0-0-3	2
	Total		**17**

Semester - III			
Name of the subject	Subject type	L-T-P	Credits
Elective	Elective-6 (Depth/Breadth)	3-0-0/4-0-0/3-1-0	3/4
Summer Internship	Core	0-0-0	4
Project (MTP-2)	Core	0-0-0	16
	Total		**23/24**

Semester - IV			
Name of the subject	Subject type	L-T-P	Credits
Elective	Elective-7 (Depth/Breadth)	3-0-0/4-0-0/3-1-0	3/4
Project (MTP-3)	Core	0-0-0	20
	Total		**23/24**

Annexure 1: List of Depth Electives (1, 3, 4, 6, 7)				
Semester	Subject Code	Subject	L-T-P	Credit
Autumn	WM60005	Climate Impact on Water Resources	3-0-0	3
Autumn	WM60008	Geogenic Water Pollution and Control	3-0-0	3
Autumn	WM60009	Aquatic Ecology and Microbiology	3-0-0	3
Spring	WM60006	Flood Assessment and Management	3-0-0	3
Spring	WM60016	Water Economics and Governance	3-0-0	3
Spring	WM60010	Disaster Management	3-0-0	3
Spring	WM60014	Fate and Transport of Contaminants in Water	3-0-0	3

Annexure 2: List of Depth Electives (2, 5, 6, 7)				
Semester	Subject Code	Subject	L-T-P	Credit
Autumn	CE60001	Free Surface Flow	4-0-0	4
Autumn	CE60023	Wastewater Management	4-0-0	4
Autumn	CE60131	Environmental Chemistry and Microbiology	3-0-0	3
Autumn	AI61005	Artificial Intelligence : Foundations and Applications	3-1-0	4
Autumn	CS61061	Data Analytics	3-1-0	4
Autumn	MA61019	Optimization Techniques	3-1-0	4
Autumn	MA61025	Time Series and Forecasting Methods	3-1-0	4
Spring	CE60140	Environmental Impact Assessment	3-0-0	3
Spring	CE60028	Industrial Water Pollution Control	4-0-0	4
Spring	AI60002	Machine Learning for Earth System Sciences	3-0-0	3
Spring	AI60004	Big Data Processing	3-0-0	3
Spring	MA61046	Multi-objective Programming	3-1-0	4
Spring	AI61004	Statistical Foundation for Artificial Intelligence and Machine Learning	3-1-0	4

Syllabus for the Subjects offered by the School of Water Resources

SUBJECT NO- WM60007, SUBJECT NAME- ENVIRONMENTAL HYDROLOGY AND HYDRAULICS LTP- 4-0-0, CRD- 4

Introduction and Overview: Concept of environmental hydrology, importance to society, hydrologic cycle description, groundwater and surface water flow, watersheds, drainage basins and catchments, resistance time, path of least resistance.
Interactions between Atmospheric, Surface and Subsurface Water: Rainfall-Runoff: causes of precipitation, measurements, time trends, frequency distribution, prediction techniques, storm and stream hydrographs, factors affecting hydrograph shape, theoretical and empirical rainfall-runoff relationships, design storm and IDF curves, flow routing, storm based peak runoff predictions.
Evapotranspiration: governing factors, potential vs actual evapotranspiration, estimation and measurements, role in soil water budget.
Infiltration: soil water balance, factors determining infiltration rates, porosity, saturation, and soil water content, field capacity and capillary action, estimating infiltration rates, artificial infiltration methods.
Groundwater transport: Flow characterization, groundwater storage and extraction.
Surface Water and Groundwater Flow: Characteristics of fluid flow, critical, subcritical and supercritical flows, open channel and pipe flow, major and minor head losses, friction factors, hydraulic jump, flood propagation, stage-discharge relations for open channels, groundwater hydraulics, drawdown discharge relations for confined and unconfined aquifers, steady and unsteady flow into wells, Dupuit approximations, single and multi-well system, well interferences, well losses.
Human Interventions on Hydrologic Cycle: Impacts on water quantity and quality, groundwater vulnerability, impacts of flow controls in natural streams, groundwater extraction and artificial recharge, crop practices and irrigation, waste disposal, rainwater harvesting, effect of climate change, local, regional and global extent of issues, quantitative estimation of effects, flow-net modelling, prediction and solute transport and attenuation.
Prevention and Remedial Measures: Need of holistic planning approach, groundwater protection and

clean-up, restoration of lakes, streams and aquifers, storm water management, improvements of water supply systems and integrated waste management, rain gardens, soil conversation, efficient and optimum irrigation adaptation etc., relevant case studies.

SUBJECT NO- WM60011, SUBJECT NAME- SECTORAL WATER DEMAND AND DISTRIBUTION LTP- 4-0-0, CRD- 4

Introduction to water distribution system to different sectors: Domestic, Industrial, Agricultural. Present status of water distribution system in India and Abroad. Types of distribution system: Pipe network, canal network system, lift irrigation. Sources of water distribution system: surface storage reservoirs and run-of-the-river (weirs/ barrages) diversion schemes, surface ponds, open wells, dug wells, tube wells, infiltration galleries, collector wells. Flow mass curve analysis for design of reservoir capacity. Water demand supply analysis through population forecasting. Drinking and irrigation water quality standards. Assessment of drinking and irrigation water demands. Components of domestic water supply system; Hydraulics of domestic pipe network design: Single network, looped network. Minimization of losses in domestic water supply system. Pumping systems and storage structures. Design of pressurized distribution system with associated controls and storage structures for drinking and irrigation water supplies; Introduction to pipe network design software EPANET. Automation techniques for drinking water distribution systems using SCADA. Principles of Canal system design. Overview of major and minor conveyance and distribution systems for irrigation water (canals, control structures, cross drainage works, distributaries, water courses and field channel for gravity irrigation) including the design of these systems; lift irrigation system. Canal hydraulics (computer simulation) models, canal scheduling (Warabandi, Shejpali, rotational), Computer models of canal operation. Design of pressurized irrigation system (Drip and Sprinkler system).

SUBJECT NO- WM69007, SUBJECT NAME- PLANNING AND DESIGN OF WATER ENGINEERING FACILITIES LTP- 0-0-3, CRD- 2

Various components of water supply systems, water distribution system, and wastewater treatment and conveyance system, design of conventional water treatment plant: Process and hydraulics, general arrangement of different components, such as Rapid mix, flocculation and sedimentation, filtration, disinfection, etc. design of raw and clear water pumping main, design of water distribution network including related software applications, design of iron-arsenic treatment plants, design of sewerage network, design of different components of conventional wastewater treatment plant, such as, screen, grit chamber, primary and secondary sedimentation, biological system, etc., Design of water harvesting structures.

SUBJECT NO- WM69005, SUBJECT NAME- GEO INFORMATICS LABORATORY LTP- 0-0-3, CRD- 2

Introduction to geographic information system, coordinate systems, thematic mapping of water resources information, terrain analysis using digital elevation models, watershed delineation, river networks, catchment geomorphic analysis, resampling, floodplain mapping, land use land cover mapping.

SUBJECT NO- WM61002, SUBJECT NAME- RIVER BASIN PLANNING AND MANAGEMENT LTP- 3-1-0, CRD- 4

Introduction to Integrated River Basin Management; Water scarcity issues: present and future status; Inter and Intra-basin water transfer issues; Concepts of water footprint (blue, green, grey and virtual water), water use efficiency and their assessment.
River Basin Fundamentals: River characteristics, flow classification, river morphology, river bends and meandering, bifurcation and confluences.
Use of flood routing models in sectoral water allocation policy issues.
Principles of River Basin Planning Processes; Water Allocation Principles and Policies; Computer models for Integrated River Basin management.
Regional Water Demands for Domestic, Agricultural and Industrial uses. Surface water and groundwater

resources assessment techniques.
Environment flow: Definition and hierarchical assessment methods.
Fundamentals of solute transport dynamics in rivers; Concept of surface water and groundwater interactions. River infiltration. Sources of water pollution (point and non-point sources) at basin scale and their management.
Soil erosion management: Soil erosion, river bank erosion, management options.
Reservoir operation policies; Optimization techniques for multi-purpose reservoir systems operation; Modeling and analysis approaches.
Flood management: Structural and non-structural measures, Floodplain zoning, Flood risk analysis, Flood forecasting and warning system.
Drought management: Types of drought, Drought indicators, mitigation options.

SUBJECT NO- WM69006, SUBJECT NAME- WATER ENGINEERING LABORATORY LTP- 0-0-3, CRD- 2

Hydrology Labs: Instruments used in hydro-meteorology, measurement of major and minor friction head losses in series and parallel pipe networks, field-scale infiltration test and its analysis, in situ determination of soil moisture using Time Domain Reflectrometry probes, computation of crop water requirements and irrigation schedule using lysimeter, Groundwater investigation by Resistivity Meter, preparation of groundwater contour maps and their analysis using flow net, seepage analysis through the base of a hydraulic structure, Acoustic Doppler Current Profiler (ADCP) survey of river and static water bodies.
Water Quality Labs: Water characteristics and quality determination; physical, chemical and bacteriological analysis of water, BOD test, alum dose, settling tests, filtration, Langalier's index and flocculation tests.

SUBJECT NO- WM60005, SUBJECT NAME- CLIMATE IMPACT ON WATER RESOURCES LTP- 3-0-0, CRD- 3

Introduction to weather and climate. Physics of climate. Impact of climate on environment. El-Nino, La-Lina, IOD (Indian Ocean Dipole), NAO (North Atlantic Oscillation), Arctic Oscillation, Indian Summer Monsoon. Precipitation and temperature change due to climate variations. Generation of extreme events. Water bodies on the earth and their variations due to change of climate. Relations among climate, vegetation and water.
Why to study climate change? Earth's natural greenhouse effect vs. human induced Earth's natural greenhouse effect, industrial revolution and Global variation on CO2, How was the past climate then?
Glossary of Climate Change, history of climate change debates, evidences of climate change, Climate models and Scenarios, GCMs, RCMs, SRES scenario families, RCP scenarios, SSP Scenarios.
Global efforts to address climate change, IPCC –structure, mandate, roles and responsibilities, UNFCC-structure, objectives, Conference of the Parties (COP).
Global Water Cycle, climate system and change, climate/weather variables and instruments to measure it, quantitative and qualitative spatio-temporal changes in water attributes, Modelling climate Impacts on Hydrological Systems, indicators of climate risks to water resources.
Climate change effects on Coasts and Delta, climate change impacts on hydrology-storms, floods, droughts, human health and agriculture.
Climate mitigation and adaptation implications on water, coping vs. adapting capacity, barriers adaptation strategies, top-down, bottom-up approaches, climate adaptation models.
Successful adaptation, success deciding criteria, climate resilience frameworks, India's Intended Nationally Determined Contribution (INDC).

SUBJECT NO- WM60008, SUBJECT NAME- GEOGENIC WATER POLLUTION AND CONTROL LTP- 3-0-0, CRD- 3

Water pollution, water quality parameters, Sources of geogenic water pollution; Arsenic and fluoride pollution: Source, occurrence, health effect, Treatment methods, Acid Mine Drainage: Causes, impact and remedial techniques, Iron and manganese pollution: Occurrence, health effect, aesthetic and operational

problems, treatment methods; Heavy Metals Pollution, Toxicity, Risk; Chromium pollution: Source, occurrence, health effect, onsite and excite Treatment methods, Nitrate pollution: Occurrence and treatment methods. Various Radioactive emissions, issues and management of radioactive pollution from Uranium, Radon, Strontium, Various ex-situ and in-situ treatment methods for geogenic pollutants.

SUBJECT NO- WM60009, SUBJECT NAME- AQUATIC ECOLOGY AND MICROBIOLOGY LTP- 3-0-0, CRD- 3

Ecology: Introduction to water distribution systems for domestic, industrial, and agricultural sectors. Introduction to ecology and ecosystems, ecosystem concepts, scale, structure, function and services, major types of aquatic systems, mass and energy flow in ecosystems, population ecology, population growth models, density-independent and density-dependent growth, species interactions, prey-predator population modelling, species extinctions, biodiversity, habitat conservation and preservation, species susceptibility to water pollution, climate changes, invasive species, natural and anthropogenic disturbances.
Environmental Microbiology: Microbial diversity, microbial species and their characteristics, microbial growth, mathematical modelling of microbial growth, adaption of microorganism to various ecosystems, identification and quantification of biomass, aerobic and anaerobic respiration, microbial photosynthesis, catabolism and co-metabolism, issues and challenges in bioremediation and biodegradation, bioavailability and biodegradability, biodegradation of toxic and persistent contaminants, degradation inhibiters.

SUBJECT NO- WM60006, SUBJECT NAME- FLOOD ASSESSMENT AND MANAGEMENT LTP- 3-0-0, CRD- 3

Definition of flood and flood index. Annual and inter annual variations of flood. El-Nino, La-in a, Indian Ocean Dipole (IOD) and their impact on Indian regional climate. Physics of precipitation. Precipitation pattern over the country. Indian Monsoons, agriculture and flood. Theory of flash flood events. Flood analysis. Flood routing in channels and reservoirs. Urban flooding and management. River flooding – causes. Structural and non-structural flood management measures. Floodplain mapping and zoning, Flood risk assessment. Real-time flood forecasting and warning- model framework. Numerical models of flood propagation. HEC-RAS applications. Economics of flood protection, socio-political response of flood and flood protection.

SUBJECT NO- WM60016, SUBJECT NAME- WATER ECONOMICS AND GOVERNANCE LTP- 3-0-0, CRD-3

General Overview: Introduction, national and international scenario on water availability, concept of sustainable water uses, water rights, elements of water governance.
Water Pricing and Economics: Importance of water pricing, sectoral water economics, unaccounted for water, existing scenarios of water pricing in India and abroad, relevant case studies. Economic Evaluation of water projects: various methods, merits and demerits.
Water Governance in India: Existing practices on water governance in India, national water policies and water acts, water regulatory authorities, power and roles of central and state regulatory authorities, institutional arrangement and administrative controls of water service, statutory requirements and policy implementations, interstate water management initiatives, stakeholders' participation.
Water Disputes Management: Interstate and intrastate water disputes resolutions practices, judiciary involvements, tribunals for water disputes resolutions, treaties and bilateral agreements, relevant case studies.
Global Water Diplomacy: International freshwater agreements, global water treaties and trans-boundary water agreements between the countries on international water resources, multi-national water disputes and their resolution mechanisms, relevant case studies.
Challenges and Open Issues: Key challenges in water governances, fundamental reforms required, ensuring safe and equitable water distribution, environmental management, water losses minimization, subsidy verses sustainability aspects in water pricing, community awareness and participation in water governances

and management, protection of stockholders' interest.

SUBJECT NO-WM60010, SUBJECT NAME- DISASTER MANAGEMENT LTP- 3-0-0, CRD- 3

Why to study disaster management? Vision and objectives of disaster education, introduction to disaster cycle. Terminologies in disaster management – Threat, Danger, hazard, types and classifications of disasters (natural and manmade).
Adversity is Also an Opportunity, emergency-panic-rumor-presence of mind, Hazard, Vulnerability, and Risk, Types of Vulnerability. Dangers associated with Volcanoes, rankings, Earthquakes- Earthquake Waves, seismograph and seismogram, Indian Code IS 1893 Categories, Earthquake Classification.
Facts about Tsunami- Tsunami warning system, Protective measures, Morphology of landslides-classifications (fall, slide, topple, flow, spread, slump, creep), early signs and causative factors of landslides, snow and rock avalanches.
Lightning and Thunderstorms, tornadoes, dust storms, Snowstorms and Blizzards, Cyclones, Hurricanes, and Typhoons, Beaufort scale, Fujita–Pearson Scale, Saffir–Simpson Hurricane Scale, Indian Classification of Cyclonic Disturbances.
Floods and Flood Disasters, Types of Floods, flood mitigation measures, Early Warning and community awareness, Drought and Famine.
Fire disasters, Fire safety, types of fire extinguishers, Recommendations and Tips for Personal Safety and home, Recommendations and Tips for schools or kids zone, Work Place and Outdoors safety guidelines, Local Authorities responsibilities.
Guide to Earthquake Safety, Guide to Safety Against Tsunamis, Landslide Safety tips, safety guidelines during cyclone, Thunderstorms and Lightning, Safety Against Floods and fires.
India's National Disaster Management Plan (NDMP), Disaster Management Act-2005, Vision and mandates of India's NDMP, Sendai Framework, objectives of the NDMP.
India's institutional framework for disaster management – NDMA-SDMA-DDMA (structure, compositions, roles, Nodal Ministry for Management of various disasters, National Institute of Disaster Management (NIDM), National Disaster Response Force (NDRF).
DM Capacity Development activities in India, DM Disaster Management Centers and training institutions for NDRF, Civil defense act and its amendments, Financing the Relief Expenditure in India, National Disaster Response Fund, Disaster Response Reserve.
Plans for Reducing Risk and Enhancing Resilience, aims and objectives of disaster preparedness, Disaster preparedness measures (Hazard, risk and vulnerability assessments, Response mechanisms and strategies, Preparedness planning, Coordination, Information management, Early warning systems, Resource mobilization, Public education, training and rehearsals, Community-based disaster preparedness.
The need for preparedness planning, DM Plan elements, How to ensure successful plan implementation, Role of response and recovery in the disaster management, disaster recovery cycle, Key activities in response, Types of recovery, Disaster Relief Aid.
Integrated Disaster Management, system thinking in disaster management, system dynamics simulation modeling in DM, Operational Framework for Multiobjective Analysis in DM, Climate change and disaster risk reduction, climate/weather factors that contribute to disasters, Climate Adaptation through disaster risk reduction, Hyogo Framework.
Geo-informatics in disaster management - Microwave Radiometry, GIS, UAVs, ICT for disaster management.
Agencies of United Nations involved in Disaster Management, disaster risk reduction- Way forward for India.

SUBJECT NO- WM60014, SUBJECT NAME- FATE AND TRANSPORT OF CONTAMINANTS IN WATER LTP- 3-0-0, CRD- 3

General Overview: Introduction, national and international Introduction to fate and transport of contaminants, Basic properties of water, sources of water pollution, point and nonpoint sources, types of water contaminants, conservative and non-conservative pollutants, concepts of mass transfer and transformation, mass and energy balance, advection, diffusion, dispersion, advection–diffusion equation and its fundamental solutions, volatilization, leaching, sorption/desorption, chemical and photochemical

transformations, biological transformations, kinetics and equilibrium of fate processes, mathematical formulation of fate and transport processes, degradation pathways and kinetics modelling, simulation and optimization, parameter estimation, model calibration and validation, sampling and data collection for fate and transport modelling, errors in sampling and data analysis, statistical significance and hypothesis testing.

2.31 Rajendra Mishra School of Engineering Entrepreneurship

Product development in today's world has seen a major transformation in the way design, manufacturing and marketing is carried out in the industry or businesses. On one hand, there are major strides in the development of technologies for various aspects of design and manufacturing of new products or services. On the other hand it is equally important to develop businesses around these technologies to facilitate the adoption in the society and market with appropriate value. These are leading to innovation and development of new business ventures. IIT Kharagpur has a strong legacy of pioneering several new domains of education to its students to impart skills that go beyond the basic sciences and engineering professions. Starting with an undergraduate-post graduate dual degree program in 2010 wherein undergraduate students, admitted through JEE Advanced, have had the benefit of obtaining a master's in Engineering Entrepreneurship, through the Rajendra Mishra School of Engineering Entrepreneurship (RMSoEE), the institute is now opening its vistas for introducing a stronger and new program at the masters' level to students across all domains of engineering and sciences through the GATE examination.

The School of Engineering Entrepreneurship was established in 2010 under the visionary zeal of a former faculty of the institute Professor Rajendra Mishra who believed in developing a strong base in engineering education followed by an appropriate management education to be imparted to students at IIT Kharagpur. It has been envisaged that the school would respond to the fast-changing needs for innovation-driven and entrepreneur-led economic development in the country. The school has been striving to prepare young talents to think out of the box, translate ideas into marketable products and smartly execute business models to reach their benefits to the society and in the process, create great value to the nation. With a well-defined and properly tailored program, the new generation professionals will be confident to develop innovative products and rapidly bring them to market at the right value to be a sustainable technology or business case. The school has a strong mix of well-trained faculty who work along with faculty of various departments and centres and other specialty schools in the campus namely the Vinod Gupta School of Management, Rajiv Gandhi School of Intellectual Property Law, Subir Chowdhury School of Quality and Reliability etc.

This new M.Tech. program curriculum has been designed to give the students an opportunity to translate the product ideas, to test assumptions and validate customer interests. The program further enriches the understanding of essentials for technology innovation and entrepreneurship with focus on different aspects of early stage start-ups, design, marketing, finance, strategy, operations, business plan around the product ideation and development. The student will practice the pre-incubation process of problem identification, solution development, proof of concept validation and prototype development, feasibility analysis, development of business models, and developing their go-to-market strategies and launching of a new venture. A set of five mandatory core subjects will expose the students to the above with an option to select some topics of their choice from a plethora of elective subjects in a variety of electives from the school and the institute in general. These lecture classes are supported by well-planned laboratory courses providing access to several basic as well as advanced experimental facilities. This program aims to inspire students interested in advancing their own technology-based start-ups or develop innovative products within an organization. Students will be trained to think for sustainable engineering solutions strongly supported by business value creation. The students are mentored by experienced faculties, practice oriented experts and entrepreneurs to use their entrepreneurial mindset to design, create and implement; to develop capability in demonstrating innovative ideas; to harness skills and add to engineering know-how which can pave way to pursue a career in academic, research, industrial applications, or starting own ventures. As per current curricular norms, this program offers a unique feature whereby students will undertake a mandatory 8-week summer internship in either of the three categories viz. 'Industry Internship' or 'Research Internship' or 'Project Internship' under the mentorship

of an expert from the institution/ industry/ research organizations. This would be followed by a M.Tech. project having the flavour of technology innovation and entrepreneurship.

The school also has a unique set of laboratories in a variety of domains like Product Analytics and Modelling, Energy Systems, Bio Lab, Fabrication Lab, Analytics Lab, Innovation and Entrepreneurship Modeling as well as direct access to other institutional facilities like The M.N.Faruqui Innovations Centre's Design Facility and Tinkering Labs and other centres of excellence in Advance Manufacturing, Indian Knowledge Systems, Computational and Data Sciences etc. The rich and valued experience of the faculty at the school and that of other academic units of IIT Kharagpur gives the strongest impetus to any student aspiring for this program. The students also will have access to the campus incubators like Science and Technology Entrepreneurs Park (STEP), AI for Cyber Physical Systems Technology Innovation Hub, Agri-Business Incubation Centre (ABIC) and other emerging incubation centres. After completing the course, the students would be ready to take senior-level responsibilities in the diverse corporate world where entrepreneurial qualities drive success or start their own ventures. RMSoEE can be the best academic partner to your journey towards innovation and entrepreneurship.

The School offers M.Tech degree in:

RJ – Technology Innovation and Entrepreneurship

Course Content: The M. Tech in Technology Innovation and Entrepreneurship course aims to inculcate the spirit of innovation and entrepreneurship among young innovators and equip them to lead the technology-based product and service innovation and start-up activities. There are core subjects like: Entrepreneurship Essentials, Innovation in Product Development Process, Financial and Legal aspects of New Technology Ventures, Technopreneurial Marketing, Operations and Supply Chain Management. In addition there is option of choosing from elective subjects like: Digital Entrepreneurship, Introduction to Intellectual Property Law, Entrepreneurship in Social Sector, Product Development, Techno-Entrepreneurial Leadership, Engineering B-Plan Development - 1, Technology Entrepreneurship, Special Topics in Entrepreneurship, Small Business Development, Entrepreneurship in Social Sector, Frugal Engineering, Engineering Design Process, Management of Growth Ventures, Economics of Entrepreneurship, Financing New Venture, Innovation Management, Engineering B-Plan Development - 2, Crop Protection Chemicals & Technopreneurship Development, Design-Driven Innovation of the school and many more from other departments, centres and schools of the institute.

Areas of Research: Data Analytics, Health Care Management, Applications of Computer Vision and IoT, Energy Management & Sustainability, Energy Storage, New materials for Energy, Heterogeneous Catalysis, Waste Management, Bio and Agri product/tech Innovation and Management, Product Development, Manufacturing, Entrepreneurship Development.

Candidates are welcome to see details of the program on https://see.iitkgp.ac.in and contact admissions@see.iitkgp.ac.in for any clarifications on prospects of the above program

Three

General Information for Applicants

Admission to the Joint M.Tech./MCP–Ph.D programme of the Institute is open to all Indian Nationals under the following categories:

1. Regular applicants with assistantship (through GATE)
2. B. Tech students graduated / graduating (final semester) from IITs having a CGPA 8.00 or above (out of 10)
3. Sponsored applicants

The admission will be based on either GATE Score & Interview or on GATE Score only

Important Note:

1. Based on the availability of seats after the final round of allotment, an additional round of allocation (online) may be conducted to fill the vacant seats. The modalities of the additional round (if any), will be announced later in the JMP Website.

3.1 Eligibility and Assistantship for Regular Applicants (through GATE)

- Applicants under all categories must possess a Bachelor's degree in Engineering/ Technology/ Architecture or Masters degree in Science/Arts or qualifications obtained through examinations conducted by professional societies recognized by UPSC/AICTE, e.g. AMIE.
- Applicants must qualify in a GATE paper appropriate to the discipline of their qualifying degree if a GATE paper is available in such a discipline. Only for those disciplines where there is no relevant GATE paper, XE/XL/XH papers of the GATE examination is applicable.
- Candidates seeking admission to Joint M.Tech/MCP-Ph.D Programme of the Institute should have the following academic qualification.
  - For institutes a) awarding degree based on aggregate marks secured in all years of the qualifying degree OR b) awarding degree based on aggregate marks secured in the final two semesters or final year of the qualifying degree:
    - GE/OBC/EWS: Minimum of 60% marks (OR a CGPA of 6.5 on a 10 point scale)
    - SC/ST/PwD: Minimum of 55% marks (OR a CGPA of 6.0 on a 10 point scale)
  - CGPA will not be converted to percentage if the degree awarding Institute provides marks in CGPA system. Their admission will be based on the CGPA mentioned in the transcript. No conversion of marks from percentage to CGPA will be accepted.
- Admission to reserved category candidates will be as per Government of India rules.
- Applicants must be in good health. In case of any discrepancy found in the certificate of medical fitness to be submitted during registration, the opinion of the Institute Medical Officer will be final.

- Persons with Physical Disability (PwD) seeking admission to various postgraduate programmes are to appear before a medical board or or before a specific date (intimated in the final offer letter) at IIT Kharagpur. The decision of the Medical Board is final and becomes a binding to the candidate.
- Selection of applicants whose results in the qualifying degree examination are yet to be declared will be provisional, subject to the condition that all parts of the examination must be completed in all respects before the date of joining the Institute and the marksheet/certificate as evidence of passing the qualifying examination is to be submitted latest by October 31, 2024.
- B. Tech students graduated / graduating (final semester) from IITs having a CGPA 8.00 or above (out of 10) are eligible for direct admission without having to appear in either GATE. Please visit homepage of IIT Kharagpur http://www.iitkgp.ac.in for details and application procedure.
- Students in the two-year M.Tech/MCP programme will receive an assistantship of Rs. 12,400/- per month. After enrolment to PhD programme, the student will receive Rs. 37,000/- per month for the first 2 (two) years and Rs. 42,000/- per month for next 3 (three).
- An applicant admitted to a post-graduate programme with assistantship will not be eligible for admission with assistantship in any other programme at this institute or any other Institution on the basis of the same GATE scorecard.

3.2 Application Fee

The application fee is Rs. 500/- for GE/OBC/EWS Male/Transgender Candidates and Rs. 250/- for all Female or PwD/SC/ST Candidates. The application fee is non-refundable.

Fee payment has to be made in online mode and all the necessary qualifying certificates and documents have to be scanned and uploaded at the registration portal at the time of submitting the application. IIT Kharagpur does not ask to send hardcopy of the application and documents.

The candidates, who receive offers from IIT Kharagpur (based on GATE score and opt for “Accept & Freeze” on the “Common Offer Acceptance Portal (COAP)” have to pay a seat booking fee of Rs. 30,000/- (Rupees thirty thousand only) as per the existing rules of the Institute within a stipulated date as mentioned in the JMP website.

3.3 Choice of Courses

To help the candidates for giving their choice of courses list of tables mentioned in Table 3.1 are provided.

- Applicants are advised to give their choices carefully for different courses after reading the information given in the Tables. Choices of courses are to be given in order of preference.
- If the course to which an applicant is offered admission does not eventually run for any reason, the applicant will be offered admission to some other suitable course depending upon his/her GATE score. Alternatively, the applicant is free to withdraw from the programme in which case the fees and deposits paid by him/her will be refunded.
- As a guide to Regular applicants, the cut-off GATE marks to the various courses offered last year are given in Table 4.9. The cut-off marks, however, differ from year to year and, therefore, Table 4.9 is only for information and will have no direct relevance for the session 2023-2024.

Table 3.1: List of Tables

Table No.	Description
4.1	GATE Main Paper,
4.2	GATE XE Sections (Engineering Sciences) Paper
4.3	GATE XL Sections (Life Sciences) Paper
4.4	GATE XH Sections (Humanities) Paper
4.5	Qualifying degree and their respective codes
4.6 & 4.7	Qualifying discipline and their code
4.8	Programmes offered and mode of selection
4.10	Eligibility for admission to different postgraduate programmes based on GATE Paper, applicant's academic background, seat distribution and mode of selection for the year 2024-25
4.9	Paper wise GATE Score cut-off for the Joint M.Tech/MCP-Ph.D Programme 2023-24.

3.4 How to Apply (Regular Applicants through GATE Score)

Application for Joint M.Tech/MCP-Ph.D programme is to be submitted only by an ONLINE process by accessing the website https://gateoffice.iitkgp.ac.in/jmp. Candidates are required to register in the Common Offer Acceptance Portal (COAP) first before applying for Joint M.Tech/MCP-Ph.D programmes in the Institute (https://gateoffice.iitkgp.ac.in/jmp). COAP registration number will be required to apply for admission in the Institute.

The application fee is Rs. 500/- for GE/EWS/OBC Male/Transgender candidates and Rs. 250/- for all Female or PwD/SC/ST candidates. The application fee is non-refundable.

Fee payment has to be made **online only** and all other necessary qualifying certificates and documents such as caste certificates, PwD certificates etc have to be **scanned and uploaded** at the time of submitting the application. **Hardcopy of the application and documents are not required.**

However, the applicants are advised to keep a copy of the completed application form for their record.

3.5 POST ADMISSION INFORMATION

Commencement of the Programme

1. Those who are offered admission are required to report to IIT Kharagpur on the date of registration (Date of Registration will be intimated later in website).
2. A copy of the qualifying degree and marks sheet is required during registration. In case the result of the final degree examination is not declared, at least all parts of the examination must be completed before the date of joining. In such a case, they will have to produce at the time of joining a course completion certificate from the Principal of the institution where the candidate studied.
3. Admission is also subject to the production of a medical fitness certificate and verification of academic transcripts at the time of registration or at any time during studies.
4. Those who are in employment, must resign and produce the acceptance of resignation by the employer at the time of joining.
5. Before registration candidate must pay the fees and deposit through online payment mode.

Accommodation

1. Both Regular and Sponsored candidates, who are offered admission, will be provided with accommodation in the Halls of Residence.
2. There is an extreme shortage of family accommodation. Therefore no family accommodation could be made available in the Institute.

Fees and Deposits

Every M.Tech/MCP student is required to pay tuition and other fees as mentioned in table 3.2

Table 3.2: Tuition Fees per Semester

Semester	**Fee type**	**General/OBC/EWS/TG (Rs.)**	**SC/ST/PwD (Rs.)**
First Semester	Non-refundable	6700.00	6700.00
	Refundable (caution money)	6000.00	6000.00
	Placement Service (not applicable for sponsored candidates)	1500.00	1500.00
	Insurance (yearly)	2500.00	2500.00
	Student Brotherhood Fund (yearly)	200.00	200.00
Each subsequent Semester	Non-refundable	10750.00	5750.00

In addition to the above, hostel fee payable per semester is mentioned in table 3.3

Table 3.3: Hostel Fees payable per semester

Fee type	Amount (Rs)
Hostel overhead	970.00
Hostel Establishment Charge	20,130.00
Mess Advance	14,500.00

Note:
Fee structure and amount are subject to change from time to time; the non-refundable fee has a tuition component of Rs 5,000.00 per semester which is waived in case of SC/ST/PwD category students

Insurance: A compulsory insurance scheme provides insurance coverage (subject to change every year) for an annual premium of Rs. 2500.00 to all the students of the Institute.

3.6 Important Dates

Table 3.4: Calender of Events

Sl No	Action	Date
1	Opening of Website for Online Application	
2	Deadline for Submission of Online Application for Admission	
3	Issue of Call Letters for Interview (Applicable only for concerned courses)	
4	Window for interviews	
5	Release of 1st and subsequent rounds of offers including interviewed candidates through COAP (Common Offer Acceptance Portal)	Please follow the JMP website for updates https://gateoffice.iitkgp.ac.in/jmp
6	Last date of acceptance of Rounds of offers	
7	Payment of Seat Booking Fees	
8	Last Date of Withdrawal	
9	Date of additional round after registration (if required)	
10	Admission to PG programs	As per Academic Calendar

Important Note: The paper wise offer made to last GATE qualified candidates/cut-offs vary from year to year and the figures given in the table should be used only as rough guidelines. No enquiry regarding the cut-off GATE scores will be entertained.

Four

Appendix: List of Tables for Reference

Table 4.1: GATE Main Paper

Sl. No.	Main Paper	Code
1	Aerospace Engineering	AE
2	Agricultural Engineering	AG
3	Architecture and Planning (Architechture-B1, Planning-B2)	AR
4	Biotechnology	BT
5	Biomedical Engineering	BM
6	Civil Engineering	CE
7	Chemical Engineering	CH
8	Computer Science and Information Technology	CS
9	Chemistry	CY
10	Data Science & Artificial Intelligence	DA
11	Ecology and Evolution	EY
12	Electronics and Communication Engineering	EC
13	Electrical Engineering	EE
14	Environmental Science & Engineering	ES
15	Geology and Geophysics	GG
16	Geomatics Engineering (Part-B Options SI OR SII)	GE
17	Instrumentation Engineering	IN
18	Mathematics	MA
19	Mechanical Engineering	ME
20	Mining Engineering	MN
21	Metallurgical Engineering	MT
22	Naval Architecture and Marine Engineering	NM
23	Petroleum Engineering	PE
24	Physics	PH
25	Production and Industrial Engineering	PI
26	Statistics	ST
27	Textile Engineering and Fibre Science	TF

Table 4.2: GATE XE Section (Engineering Sciences) Papers

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

Table 4.3: GATE XL Section (Life Sciences) Papers

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

Table 4.4: GATE XH Section (Humanities & Social Sciences) Papers

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

Table 4.5: Qualifying degrees and their codes

Qualifying Degree	**Qualifying Degree Code**
B.E./B.Tech. or equivalent	A
B. Arch./B. Plan or equivalent	B
M. Sc. with Mathematics at +2 level	C
M. Sc. with Mathematics both at +2 and B. Sc. level	D
M. Sc. with or without Mathematics background	E
MCA with Mathematics both at +2 and B. Sc. level	F

Table 4.6: Qualifying disciplines and their codes part - I

Qualifying Discipline	**Code**	**Qualifying Discipline**	**Code**
Aeronautical Engineering	AN	Computer Science and Engineering	CSE
Aerospace Engineering	AE	Computer and Communication Engg.	CCE
Agri-Informatics	AF	Cyber Security and Forensic	CSF
Agricultural Engineering	AG	Dairy Engineering/Technology	DT
Agricultural Science	AGS	Design and Manufacturing	DM
Agricultural and Irrigation Engineering	AI	Earth Sciences/Geological Sciences	ES
Aircraft Maintenance Engineering	AC	Electrical and Computer Engineering	EL
Applied Electronics and Instrumentation	AL	Electrical Engineering	EE
Applied Electronics Engineering	AP	Electrical and Electronics Engineering	EEE
Applied Mechanics	AM	Electronic Instrumentation and Control	EO
Architecture Engineering	AH	Electronics Sciences	EA
Architecture and Planning	AR	Electronics Engineering	EN
Atmospheric Science	AS	Electronics and Communication Engg.	EC
Automobile Engineering	AT	Electronics and Instrumentation Engg.	EI
Automotive Design Engineering	AD	Electronics and Media Technology	EM
Avionics Engineering	AV	Electronics and Telecommunication Engg.	ETE
Biochemical Engineering	BCH	Electronics Control System Engineering	ECS
Bio Chemistry	BC	Electronics Engineering - Design and Manufacturing	ED
Bio Engineering	BE	Energy Engineering	EY
Bio Informatics	BI	Energy Studies and Petroleum	ESP
Bio Medical Engineering	BM	Energy Technology	ET
Bio Physics	BP	Engineering Physics	EP
Bio Science	BS	Environmental Engineering	EV
Bio Technology	BT	Exploration Geophysics // Marine Geophysics	EX
Biomedical Instrumentation	BN	Fashion and Apparel Design	FD
Bioprocess Technology	BPT	Fashion Technology	FY
Biotechnology and Biochemical Engg.	BB	Fire and Safety Engineering	FS
Building Engg. and Construction Technology	BCT	Food Engineering and Technology	FET
Carpet and Textile Technology	CX	Food Process/Processing Engineering	FPE
Carpet Technology	CT	Food Technology	FT
Ceramic Engineering	CZ	Food Technology and Bio-Chemical Engg.	FB
Ceramic Technology	CW	Footware Technology	FW
Ceramics and Cement Technology	CC	Gas and Applied Petroleum Engineering	GA
Ceramic and Glass Technology	CG	Genetic Engineering	GE
Chemical and Alcohol Technology	CO	Geo Informatics Engineering	GI
Chemical and Bio Engg,	CB	Geology/Geophysics/Applied Geology/Applied Geophysics	GG
Chemical Engineering	CH	Geo Sciences Engineering	GS
Chemical Science and Technology	CJ	Harbour Engineering and Ocean Engg.	HOE
Chemical and Electrochemical Engg.	CEE	Hotel Management	HM
Chemistry/Applied Chemistry	CY	Humanities and Management	HS
Civil Engineering	CE	Industrial and Production Engineering	IP
Civil Engineering and Planning	CP	Industrial Biotechnology	IB
Civil Infrastructure Engineering	CF	Industrial Chemistry	IC
Civil and Transportation Engineering	CTE	Industrial Design	ID
Computer Applications	CA	Industrial Engineering	IE
Computer Engineering	CU	Industrial Engineering and Management	IM
Computer Science	CQ	Industrial Microbiology	IG
Computer Science and Electronic Engg.	CR	Information Science and Engineering	IS
Computer Science and Information Tech.	CS	Information Technology	IT
Computer Science and Software Engg.	CSS	Information and Communication Tech.	ICT
Infrastructure Engineering	IK	Packaging Technology	PG
Instrumentation and Control Engineering	IR	Paint Technology	PB
Instrumentation Engineering	IN	Petrochemical Engineering	PO
Interior Design	IO	Petrochemical Technology	PY

Table 4.7: Qualifying disciplines and their codes part - II

Qualifying Discipline	Code	Qualifying Discipline	Code
Irrigation and Water Management	IW	Petroleum Engineering	PE
Leather Technology	LT	Petroleum Refining and Petrochemicals Engineering	PPE
Life Sciences	LS	Petroleum and Off-shore Engineering	POE
Life Sciences (Veterinary/Animal Sc)	LV	Pharmaceutical Technology/B-pharma	PTB
Life Sciences (Botany)	LB	Photonic Engineering	PV
Life Sciences (Zoology)	LZ	Physics/Applied Physics	PH
Man-made Fibre Technology	MFT	Planning	PA
Manufacturing and Management	MM	Plastic Technology	PL
Manufacturing Engineering	MC	Plastic and Polymer Engineering	PM
Manufacturing Technology	MF	Polymer Engineering	PN
Marine Electrical and Electronics Engineering	MV	Polymer Science and Chemical Technology	PC
Marine Engineering	MR	Polymer Technology	PP
Material and Metallurgical Engineering	MME	Power Electronics	PQ
Material Science and Engineering	MS	Power Engineering	PW
Materials Science and Metal Engineering	MI	Power System Engineering	PS
Mathematics/Applied Mathematics	MA	Power Plant Engineering	POP
Mathematics and Computing	MK	Printing Engineering and Graphic Communication	PU
Mechanical and Automation Engineering	MAE	Printing Technology	PT
Mechanical and Industrial Engineering	MD	Production and Industrial Engineering	PI
Mechanical Engineering	ME	Production Engineering/Production Engg. and Management	PR
Mechanical Technology	MY	Professional Communication	PD
Mechatronics Engineering	MP	Radio Physics	RD
Medical Electronics	MQ	Robotics Engineering	RE
Metallurgical Engineering	MT	Robotics and Automation	RA
Metallurgy	MH	Rubber Technology	RT
Metallurgical Engg & Materials Science	MES	Rubber and Plastic Technology Engg	RP
Metallurgy & Materials Science	MMS	Safety and Fire Engineering	SF
Microbiology	MB	Ship Building	SB
Mineral Engineering	ML	Silk Technology	ST
Mining Engineering	MN	Software Engineering	SE
Mining Machinery	MW	Solar and Alternate Energy	SA
Missile Technology	MX	Solid State Physics	SP
Mobile Computing	MO	Space Technology	SC
Molecular and Cellular Engineering	MZ	Statistics/Applied Statistics	SS
Nanotechnology	NT	Sugar Technology	SU
Naval Architecture	NA	Sugar and Alcohol Technology	SL
Naval Architecture and Offshore Engineering	NF	Telecommunication Engineering	TE
Naval Architecture and Ship Building	NB	Textile Chemistry	TC
Naval Architecture & Ocean Engg	NO	Textile Engg/Fiber Sc. Engg	TF
Nuclear Power Technology	NP	Textile Technology	TT
Nuclear Science and Engineering	NS	Transportation Engineering	TR
Ocean Engineering	OE	Upstream & Applied Petroleum Engg	UP
Oil and Gas Informatics	OG	Water Resources Engineering	WR
Oil Technology	OT	Welding Technology	WT
Operational Research	OR	Electrical Electronics and Power	EEP
Optics and Optoelectronics	OP	Financial Economics	FEC
Physical Sciences	PSC	Computer Science & System Engineering	CYE
Chemical Technology	CHT	Computer Technology	CTT
Polymer & Coating Technology	PCT	Polymer Science & Technology	PST
Polymer Engg & Technology	PET	Jute & Fibre Technology	JFT
Construction Engineering	CEN	MSc in Bio Medical Science	BMS
Agricultural Biotechnology	ABT	Applied Microbiology	AMB
Polymer Science	POS	Facilities and Services Planning	FSP
Earth & Environmental Science	EVS	Artificial Intelligence and Data Science	ADS

Table 4.8: Programmes Offered and Mode of Selection

Name of Department/Centre/School	Name of Programme (Code)	Mode of Selection
AEROSPACE ENGINEERING	Aerospace Engineering (AE)	Direct
AGRICULTURAL AND FOOD ENGINEERING	Farm Machinery and Power (AG1)	Direct
	Land and Water Resources Engineering (AG2)	Direct
	Food Process Engineering (AG3)	Direct
	Agricultural Biotechnology (AG4)	Direct
	Aquacultural Engineering (AG5)	Direct
	Agricultural Systems and Management (AG6)	Direct
ARCHITECTURE AND REGIONAL PLANNING	City Planning (AR)	Direct
	Master of Architecture (Sustainable Built Environments) (AR1)	Direct
ADVANCED TECHNOLOGY DEVELOPMENT CENTRE	Embedded Controls and Software (AT1)	Direct
	Electric Transportation (AT2)	Direct
BIOTECHNOLOGY	Biotechnology and Biochemical Engineering (BT)	Direct
CIVIL ENGINEERING	Hydraulic and Water Resources Engineering (CE1)	Direct
	Transportation Engineering (CE2)	Direct
	Environmental Engg. and Management (CE3)	Direct
	Geotechnical Engineering (CE4)	Direct
	Structural Engineering (CE5)	Direct
CHEMICAL ENGINEERING	Chemical Engineering (CH)	Direct
CENTRE FOR OCEANS, RIVERS, ATMOSPHERE & LAND SCIENCES	Earth System Science and Technology (CL)	Direct
CRYOGENIC ENGINEERING	Cryogenic Engineering (CR)	Interview
COMPUTER SCIENCE & ENGINEERING	Computer Science and Engineering (CS)	Direct
CENTRE OF EXCELLENCE IN ARTIFICIAL INTELLIGENCE	Artificial Intelligence (AI)	Interview
CENTRE OF EXCELLENCE IN SAFETY ENGINEERING AND ANALYTICS	Safety Engineering and Analytics (SE)	Direct
ELECTRONICS & ELECTRICAL COMMUNICATION ENGG.	Microelectronics and VLSI Circuits (EC2)	Direct
	RF and Microwave Engineering (EC3)	Direct
	Communications and Signal Processing (EC4)	Direct
	Vision and Intelligent Systems (EC5)	Direct
ELECTRICAL ENGINEERING	Machine Drives and Power Electronics (EE1)	Interview
	Control System Engineering (EE2)	Interview
	Power and Energy Systems (EE3)	Interview
	Instrumentation and Integrated Electronics (EE4)	Interview
	Signal Processing & Machine Learning (EE5)	Interview

Name of Department/Centre/School	Name of Programme (Code)	Mode of Selection
ENERGY SCIENCE AND ENGINEERING	Renewable Energy Technologies (ES)	Direct
GEOLOGY & GEOPHYSICS	Exploration Geosciences (GG1)	Direct
G S SANYAL SCHOOL OF TELECOMMUNICATIONS	Wireless Communications and Networks (GS)	Direct
RANBIR & CHITRA GUPTA SCHOOL OF INFRASTRUCTURE DESIGN & MANAGEMENT	Infrastructure Design and Management (ID)	Direct
INDUSTRIAL AND SYSTEMS ENGINEERING	Industrial Engineering and Management (IM)	Direct
	Operations Research and Data Analytics (IM1)	Direct
MATHEMATICS	Computer Science and Data Processing (MA)	Direct
MECHANICAL ENGINEERING	Manufacturing Science and Engineering (ME1)	Direct
	Thermal and Fluids Engineering (ME2)	Direct
	Mechanical Systems Design (ME3)	Direct
MINING ENGINEERING	Safety, Health and Environment (MI1)	Direct
	Geomechanics for Mineral and Energy Resources (MI2)	Direct
SCHOOL OF MEDICAL SCIENCE & TECHNOLOGY	Biomedical Engineering (SM1)	Direct
	Medical imaging and Informatics (SM2)	Direct
MATERIALS SCIENCE CENTRE	Materials Science and Engineering (MS)	Direct
METALLURGICAL & MATERIALS ENGINEERING	Metal and Materials Engg (MT)	Direct
OCEAN ENGENEERING AND NAVAL ARCHITECTURE	Ocean Engineering and Naval Architecture (NA)	Direct
PHYSICS	Functional Materials and Devices (PH1)	Direct
SUBIR CHOWDHURY SCHOOL OF QUALITY & RELIABILITY	Qualify and Reliability Engineering (RE)	Direct
RAJENDRA MISHRA SCHOOL OF ENGG ENTREPRENEURSHIP	Technology Innovation and Entrepreneurship (RJ)	Direct
RUBBER TECHNOLOGY	Rubber Technology (RT)	Direct
SCHOOL OF WATER RESOURCES	Water Engineering and Management (WM)	Direct

JMP - 2023 GATE Score Cut-off

Program Code	Major					Minor					PwD
	GEN	EWS	OBC	SC	ST	GEN	EWS	OBC	SC	ST	
AE	509	380	446	246	236	562	425	515	331	259	247
AG1	514	488	379	268	225	418	-	342	251	-	-
AG2	446	360	283	109	157	450	-	395	347	-	321
AG3	533	466	321	264	283	558	443	452	360	304	576
AG4	549	309	403	314	299	521	382	445	310	-	189
AG5	360	350	283	176	118	391	-	378	253	-	-
AG6	362	321	283	244	147	521	-	346	170	-	-
AR1	668	444	532	310	411	-	-	-	-	-	-
AR2	595	439	436	277	299	-	-	-	-	-	278
AT1	668	664	592	434	371	-	-	-	-	-	352
AT2	543	464	493	401	253	556	-	482	426	-	236
BT	596	325	388	351	242	557	497	339	346	-	
CE1	513	466	399	356	351	-	-	-	-	-	267
CE2	629	585	505	447	362	-	-	-	-	-	339
CE3	547	476	459	407	377	-	-	-	-	-	255
CE4	534	518	458	434	398	-	-	-	-	-	255
CE5	640	589	537	522	390	-	-	-	-	-	255
CH	482	349	353	231	247		-	-	-	-	219
CL	446	361	371	277	295		-	-	-	-	254
CR	361	320	421	273	292	500	474	413	274	-	-
CS	694	637	630	486	389	-	-	-	-	-	374
EC2	733	621	654	451	413	-	-	-	-	-	335
EC3	546	505	455	330	227	-	-	-	-	-	310
EC4	604	579	550	338	264	-	-	-	-	-	-
EC5	579	476	413	360	231	-	-	-	-	-	267
EE1	555	549	486	396	242	-	-	-	-	-	-
EE2	543	475	424	324	231	492	-	376	268	-	282
EE3	447	469	332	287	231	-	-	-	-	-	-
EE4	623	553	599	509	344	596	-	546	491	-	-
EE5	525	476	500	239	281	-	-	-	-	-	-
ES	518	404	443	246	250	572	421	489	400	-	303
GG1	399	300	282	256	188	-	-	-	-	-	529
GS	550	451	505	358	231	-	-	-	-	-	335
ID	611	371	500	344	327	707	534	629	299	266	259
IM	683	665	635	446	418	707	582	601	539	263	202
MA	692	560	498	404	156	640	609	497	397	368	243
ME1	550	433	478	319	266	543	320	415	156	-	202
ME2	566	448	493	338	258	645	540	584	492	-	254
ME3	626	535	539	345	258	-	-	-	-	-	281
MI1	545	-	399	377	469	430	-	391	280	-	-
MI2	588	-	501	355	355	464	-	418	343	-	267
MS	432	322	333	264	195	364	321	303	-	-	-
MT	353	461	277	135	92	505	414	425	273	251	202
NA	399	312	350	254	128	500	454	434	311	295	205
PH1	444	359	306	253	195	491	400	396	306	239	236
RE	588	438	514	344	311	-	-	-	-	-	254
RJ	603	540	487	378	333	-	-	-	-	-	318
RT	404	334	314	189	228	418	394	383	254	-	320
SM1	495	442	406	199	221	528	429	398	302	-	-
SM2	398	310	344	211	246	521	333	438	333	-	465
WM	408	398	283	167	157	458	-	430	343	-	255

4.10: Eligibility and Selection Criteria to Different PG Programmes through GATE JMP 2024-2025

Course Code	Specialization	Major		Minor		Total	Mode of Selection	Degree	Discipline
		GATE Paper(s)	Seats	GATE Paper(s)	Seats				
AE	Aerospace Engineering	AE, CE, EE, ME	29			29	GATE Score	A	AC, AE, AN,CE, EE,ME, MP
AG1	Farm Machinery and Power	AG	19	ME	5	24	GATE Score	A	AG,ME
AG2	Land and Water Resources Engineering	AG	18	CE	4	22	GATE Score	A	AG,CE
AG3	Food Process Engineering	AG	26	CH, XE-G, ME	12	38	GATE Score	A	AG,CH,DT,FET,FPE,FT,ME
AG4	Agricultural Biotechnology	BT	7	XL-Q, XL-R, XL-S	9	16	GATE Score	A, C, E	ABT, AGS,BC,BT,GE,LB,LS,MB
AG5	Aquacultural Engineering	AG	10	XL-T, CE, CH	4	14	GATE Score	A, C, D	AG,CE,CH,LZ,OE
AG6	Agricultural Systems and Management	AG	9	XL-Q, XL-R, XL-S	6	15	GATE Score	A, C, D	AF,AG,AGS,AI,BC,IW,LB,MB
AR	City Planning	AR, B1, B2	52			52	GATE Score	A,B	AR,CP
AR1	Master of Architecture (Sustainable Built Environments)	AR, B1	20			20	GATE Score	B	AR
AT1	Embedded Controls and Software	CS, EC, EE, IN	14			14	GATE Score	A	CEE,CQ,CR,CS,CSE,CSF,CSS,CU,CYE,EC,ECS,ED,EE,EEE,EEP,EI,EL,EN,EO,ETE,ICT,IN,IR,IS,IT,MO,MP,RA,RD,RE,TE
AT2	Electric Transportation	EE	10	EC, IN, ME	5	15	GATE Score	A	AP,CCE,EA,EC,ECS,ED,EE,EEE,EI,EL,EM,EN,EO,ET,ETE,EY,ICT,IN,IR,ME,MK,MO,PW,RA,RE,TE
BT	Biotechnology and Biochemical Engineering	BT	10	XL-Q, XL-R, XL-S, XL-T	19	29	GATE Score	A,C	AMB,BB,BC,BCH,BE,BP,BPT,BS,BT,GE,IB,LB,LS,LV,LZ,MB,MZ
CE1	Hydraulic and Water Resources Engineering	CE	25			25	GATE Score	A	CE
CE2	Transportation Engineering	CE	25			25	GATE Score	A	CE
CE3	Environmental Engineering and Management	CE	18	ES	4	22	GATE Score	A	CE
CE4	Geotechnical Engineering	CE	22			22	GATE Score	A	CE
CE5	Structural Engineering	CE	25			25	GATE Score	A	CE
CH	Chemical Engineering	CH	70			70	GATE Score	A	CH
CL	Earth System Science and Technology	AE, AG, XE-B, CE, CH, GG-G2, XE-H, MA, ME, PH, NM	18	DA	2	20	GATE Score	A,D	AE,AG,AGS,AS,CE,CH,CQ,CSE,EP,GG,MA,ME,MK,NF,NO,OE,PH
CR	Cryogenic Engineering	AE, XE-B , XE-E EE, IN, ME	12	XE-C, CH, PH	6	18	GATE Score + Interview	A,D	AE,CH,CHT,CJ,EE,EEE,EI,EO,EP,ET,EY,GA,IN,IR,MD,ME,PH,PO,POE,PSC,SC,SP
CS	Computer Science and Engineering	CS	84			84	GATE Score	A,D,F	AL,AP,CA,CCE,CQ,CR,CS,CSE,CSS,CTT,CU,CYE,EC,ECS,EE,EEE,EI,EL,ELC,EN,ETE,ICT,IS,IT,MK,SE,TE

4.10: Eligibility and S election Criteria to Different PG Programmes through GATE JMP 2024-2025									
Course Code	Specialization	Major		Minor			Mode of Selection	Degree	Discipline
		GATE Paper(s)	Seats	GATE Paper(s)	Seats	Total			
EC2	Microelectronics and VLSI Circuits	EC	38			38	GATE Score	A	EC,EEE,EI,EN,ETE
EC3	RF and Microwave Engineering	EC	34			34	GATE Score	A	EC,EEE,ETE
EC4	Communications and Signal Processing	EC	34			34	GATE Score	A	EC,ETE
EC5	Vision and Intelligent Systems	EC	34			34	GATE Score	A	EC,EEE,ELC,ETE
EE1	Machine Drives and Power Electronics	EE	22			22	GATE Score + Interview	A	EE,EEE,PQ,PW
EE2	Control System Engineering	EE, IN	16	EC	6	22	GATE Score + Interview	A	AL,AP,EC,ECS,EE,EEE,EI,EO,ETE,IN,IR,RA,RE
EE3	Power and Energy Systems	EE	22			22	GATE Score + Interview	A	EE,EEE,POP,PQ,PS,PW
EE4	Instrumentation and Integrated Electronics	EE, IN	16	EC	6	22	GATE Score + Interview	A	AL,AP,BN,EA,EC,ECS,ED,EE,EEE,EI,EL,EM,EN,EO,ETE,IN,IR,MQ,OP,RA,RD,RE,TE
EE5	Signal Processing And Machine Learning	EE	13	IN, EC, DA	12	25	GATE Score + Interview	A	AP,CCE,EA,EC,ECS,ED,EE,EEE,EI,EL,EN,EO,ETE,ICT,IN,IR,MK,MO,RA,RD,RE,TE
ES	Renewable Energy Technologies	XE-B, BT, XE-C, CY, XE-E, XE-F, PH, XL-Q	12	ME, MN, MT, PE, PI	8	20	GATE Score	A,D	ABT,AD,AE,AF,AG,AGS,AL,AM,AMB,AP,AT,BB,BC,BCH,BCT,BE,BI,BP,BPT,BS,BT,CB,CCE,CE,CEE,CF,CH,CHT,CJ,CO,CP,CQ,CR,CS,CSE,CSS,CTE,CTT,CU,CY,CYE,EA,EC,ECS,ED,EE,EEE,EEP,EI,EL,ELC,EN,EO,EP,ESP,ET,ETE,EV,EY,GA,IB,IC,IG,IN,MB,MD,ME,MES,MH,MI,MME,MMS,MP,MS,MT,MV,MY,NT,PE,PH,PO,POP,PQ,PS,PW,PY,SA,SP,TR
GG1	Exploration Geosciences	ES, GG-G1, GG-G2	22			22	GATE Score	D	ES,EVS,EX,GG,GS
GS	Wireless Communications and Networks	EC	24			24	GATE Score	A	AL,AP,AV,CA,CCE,CQ,CR,CS,CSE,CSS,CTT,CU,CYE,EA,EC,ECS,ED,EE,EEE,EEP,EI,EL,ELC,EM,EN,EO,ETE,ICT,IN,IR,IS,IT,MK,MO,MP,MQ,MV,OP,PQ,PS,PV,RD,SE,TE
ID	Infrastructure Design and Management			AR, B1, B2, B-SI, B-SII, CE	40	40	GATE Score	A,B	AH,AR,CE,CF,CP,CTE,GI,GS,IK,PA,TR
IM	Industrial Engineering and Management	CE, CS, EC, EE, ME, PI	16	AE, AG, CH, IN, MN, MT, ST	8	24	GATE Score	A	AE,AG,AN,CCE,CE,CH,CQ,CR,CS,CSE,CSS,CTE,CU,DM,EC,ED,EE,EEE,EI,EL,ELC,EN,ETE,ICT,ID,IE,IM,IN,IP,IR,IT,MC,MD,ME,MES,MF,MH,MI,MK,MM,MME,MMS,MN,MS,MT,OR,PR,TR

4.10: Eligibility and Selection Criteria to Different PG Programmes through GATE JMP 2024-2025									
Course Code	Specialization	Major		Minor			Mode of Selection	Degree	Discipline
		GATE Paper(s)	Seats	GATE Paper(s)	Seats	Total			
IM1	Operations Research and Data Analytics	CE, CH, CS, EC, EE, IN, ME, PI	14	AE, AG, MN, MT, NM, DA	6	20	GATE Score	A	ABT,AC,AD,AE,AF,AG,AGS,AH,AI,AL,AM,AMB,AN,AP,AR,AS,AT,AV,BB,BC,BCH,BCT,BE,BI,BM,BMS,BN,BP,BPT,BS,BT,CA,CB,CC,CCE,CE,CEE,CEN,CF,CG,CH,CHT,CJ,CO,CP,CQ,CR,CS,CSE,CSF,CSS,CT,CTE,CTT,CU,CW,CX,CY,CYE,CZ,DM,DT,EA,EC,ECS,ED,EE,EEE,EEP,EI,EL,ELC,EM,EN,EO,EP,ES,ESP,ET,ETE,EV,EVS,EX,EY,FB,FD,FEC,FET,FPE,FS,FSP,FT,FW,FY,GA,GE,GG,GI,GS,HM,HOE,HS,IB,IC,ICT,ID,IE,IG,IK,IM,IN,IO,IP,IR,IS,IT,IW,JFT,LB,LS,LT,LV,LZ,MA,MAE,MB,MC,MD,ME,MES,MF,MFT,MH,MI,MK,ML,MM,MME,MMS,MN,MO,MP,MQ,MR,MS,MT,MV,MW,MX,MY,MZ,NA,NB,NF,NO,NP,NS,NT,OE,OG,OP,OR,OT,PA,PB,PC,PCT,PD,PE,PET,PG,PH,PI,PL,PM,PN,PO,POE,POP,POS,PP,PPE,PQ,PR,PS,PSC,PST,PT,PTB,PU,PV,PW,PY,RA,RD,RE,RP,RT,SA,SB,SC,SE,SF,SL,SP,SS,ST,SU,TC,TE,TF,TR,TT,UP,WR,WT
MA	Computer Science and Data Processing	MA	27	EC, EE, PH	14	41	GATE Score	A,C,D	EC,EEE,MA, PH
ME1	Manufacturing Science and Engineering	ME	24	PI	8	32	GATE Score	A	IP,MC,MD,ME,MF,MT,PI,PR
ME2	Thermal and Fluids Engineering	ME	33	AE, XE-B, XE-E	8	41	GATE Score	A	AE,AN,ME,PW
ME3	Mechanical Systems Design	ME	54			54	GATE Score	A	AE,AM,AN,ME,MY
MI1	Safety, Health and Environment	MN, CE, PE	11			11	GATE Score	A	CE,MN,PE
MI2	Geomechanics for Mineral and Energy Resources	MN, CE, CH, EE, ME, PE, PI	11			11	GATE Score	A	CE,CH,EE,ME,MN,PE,PI
MS	Materials Science and Engineering	CY, PH	28	XE-C, XE-F	10	38	GATE Score	A,C,D	CC,CG,CW,CY,CZ,EA,EP,IC,MS,NT,PC,PET,PH,PL,PM,PN,POS,PP,RP,RT,SA,SP
MT	Metal and Materials Engineering	MT	40	XE-C, CH, ME, PI	27	67	GATE Score	A	MES,MH,MI,MME,MMS,MT
NA	Ocean Engineering and Naval Architecture	NM, AE, XE-B, CE, XE-D, XE-E, ME, PI	25			25	GATE Score	A	AC,AE,AM,AN,AT,CE,CEN,CF,CP,CTE,DM,HOE,IE,IM,IP,MAE,MC,MD,ME,MP,MR,MY,NA,NB,NF,NO,OE,SB,TR,WT
PH1	Functional Materials and Devices	PH	14	XE-C, EC, EE, IN	11	25	GATE Score	A,D	EA,EC,ECS,ED,EE,EEE,EEP,EI,EL,ELC,EM,EN,EO,EP,ET,ETE,EY,IR,MH,MI,MME,MMS,MS,MT,PH,PSC,PW,RD,SA,SP,TE

4.10: Eligibility and S election Criteria to Different PG Programmes through GATE JMP 2024-2025									
Course Code	Specialization	Major		Minor			Mode of Selection	Degree	Discipline
		GATE Paper(s)	Seats	GATE Paper(s)	Seats	Total			
RE	Quality and Reliability Engineering	AE, CH, CS, EC, EE, IN, ME, NM PI	18	CE, MN	7	25	GATE Score	A	AC,AE,AN,AP,AT,AV,BCT,CCE,CE,CEN,CF,CH,CHT,CJ,CP,CR,CS,CSE,CTE,CTT,CU,CYE,DM,EC,ECS,ED,EE,EEE,EEP,EI,EL,ELC,EN,EO,ET,ETE,EY,IE,IK,IM,IN,IR,MAE,MC,MD,ME,MF,MK,MM,MN,MV,MW,MX,MY,NA,NB,NF,NO,NP,NS,POP,PQ,PR,PS,PW,RA,RE,SB,SC,TE,TR
RJ	Technology Innovation and Entrepreneurship	AE, AG, AR, XE-B, AR-B1, AR-B2, BM, GE-B-SI, GE-B-SII, BT, XE-C, XH-C1, CE, CH, CY, DA, XE-E, EC, EE, ES, XE-F, XE-G, IN, MA, ME, MN, MT, NM, PH, PI, XL-Q, XL-S, TF, XL-U	20			20	GATE Score	A,B,D, F	ABT,AC,AD,AE,AF,AG,AGS,AH,AI,AL,AM,AMB,AN,AP,AR,AS,AT,AV,BB,BC,BCH,BCT,BE,BI,BM,BMS,BN,BP,BPT,BS,BT,CA,CB,CC,CCE,CE,CEE,CEN,CF,CG,CH,CHT,CJ,CO,CP,CQ,CR,CS,CSE,CSF,CSS,CT,CTE,CTT,CU,CW,CX,CY,CYE,CZ,DM,DT,EA,EC,ECS,ED,EE,EEE,EEP,EI,EL,ELC,EM,EN,EO,EP,ES,ESP,ET,ETE,EV,EVS,EX,EY,FB,FD,FEC,FET,FPE,FS,FSP,FT,FW,FY,GA,GE,GG,GI,GS,HM,HOE,HS,IB,IC,ICT,ID,IE,IG,IK,IM,IN,IO,IP,IR,IS,IT,IW,JFT,LB,LS,LT,LV,LZ,MA,MAE,MB,MC,MD,ME,MES,MF,MFT,MH,MI,MK,ML,MM,MME,MMS,MN,MO,MP,MQ,MR,MS,MT,MV,MW,MX,MY,MZ,NA,NB,NF,NO,NP,NS,NT,OE,OG,OP,OR,OT,PA,PB,PC,PCT,PD,PE,PET,PG,PH,PI,PL,PM,PN,PO,POE,POP,POS,PP,PPE,PQ,PR,PS,PSC,PST,PT,PTB,PU,PV,PW,PY,RA,RD,RE,RP,RT,SA,SB,SC,SE,SF,SL,SP,SS,ST,SU,TC,TE,TF,TR,TT,UP,WR,WT
RT	Rubber Technology	XE-E, XE-C, CH, CY, XE-F	18	XE-B, ME, PE, PI, TF, XL-U	14	32	GATE Score	A, C	CH,CHT,CJ,CO,CY,ESP,FW,IC,IE,JFT,MD,ME,MES,MFT,MI,MME,MS,NT,PB,PC,PCT,PET,PG,PI,PL,PM,PN,PO,POS,PP,PST,PT,RP,RT,TC,TF,TT
MM2	Biomedical Engineering	BM, EE, IN, PH, ST	12	BT, CS, EC, MA	8	20	GATE Score	A,D	AL,BM,BN,CSE,EC,EE,EEE,EI,EO,IR,MQ
MM1	Medical Imaging and Informatics	BM, EE, IN, ST	12	BT, CS, EC, PH	8	20	GATE Score	A,D	AL,BI,BM,BN,BP,BT,CSE,EC,EE,EI,EO,IN,MP,MQ,PH
WM	Water Engineering and Management	AG	7	CE, CH	7	14	GATE Score	A	AG,CE,CH
AI	Artificial Intelligence	CS, DA	30	EC, EE	10	40	GATE Score + Interview	A,D,F	ABT,AC,AD,ADS,AE,AF,AG,AGS,AH,AI,AL,AM,AMB,AN,AP,AR,AS,AT,AV,BB,BC,BCH,BCT,BE,BI,BM,BMS,BN,BP,BPT,BS,BT,CA,CB,CC,CCE,CE,CEE,CEN,CF,CG,CH,CHT,CJ,CO,CP,CQ,CR,CS,CSE,CSF,CSS,CT,CTE,CTT,CU,CW,CX,CY,CYE,CZ,DM,DT,EA,EC,ECS,ED,EE,EEE,EEP,EI,EL,ELC,EM,EN,EO,EP,ES,ESP,ET,ETE,EV,EVS,EX,EY,FB,FD,FEC,FET,FPE,FS,FSP,FT,FW,FY,GA,GE,GG,GI,GS,HM,HOE,HS,IB,IC,ICT,ID,IE,IG,IK,IM,IN,IO,IP,IR,IS,IT,IW,JFT,LB,LS,LT,LV,LZ,MA,MAE,MB,MC,MD,ME,MES,MF,MFT,MH,MI,MK,ML,MM,MME,MMS,MN,MO,MP,MQ,MR,MS,MT,MV,MW,MX,MY,MZ,NA,NB,NF,NO,NP,NS,NT,OE,OG,OP,OR,OT,PA,PB,PC,PCT,PD,PE,PET,PG,PH,PI,PL,PM,PN,PO,POE,POP,POS,PP,PPE,PQ,PR,PS,PSC,PST,PT,PTB,PU,PV,PW,PY,RA,RD,RE,RP,RT,SA,SB,SC,SE,SF,SL,SP,SS,ST,SU,TC,TE,TF,TR,TT,UP,WR,WT
SE	Safety Engineering and Analytics	AE, AG, CE, CH, CS, EC, EE, ES, IN, ME, MN, MT, NM, PE, PI	10	XE-B, BT, XE-C, XE-D, XE-E, XE-F, XE-G, G1, G2, XE-H, TF, DA	5	15	GATE Score	A	AE,AG,AN,CCE,CE,CH,CQ,CR,CS,CSE,CSS,CU,EC,EE,EEE,EI,EL,EN,ETE,ICT,IE,IM,IN,IP,IR,IS,IT,MA,MC,MD,ME,MES,MF,MME,MN,MT,PI,PR,PS,PW