Joint M.Tech./MCP-Ph.D. Programme 2021 - 2022

Indian Institute of Technology Kharagpur

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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	: 19
Number of Centres	: 15
Number of Schools	: 12
Number of UG Courses	: 16
Number of Dual Degree Courses	: 16
Number of PG Courses	: 54
Number of M.Sc. Courses	: 09
Number of Law Courses	: 02

1.3 Postgraduate Degrees Conferred in the 2020

M.Tech, MCP	: 645
MBA, EMBA, MS, MMST, MHRM	: 195
M.Sc.	: 397
LLB and LLM	: 49
Dual Degree	: 536
Ph.D. conferred during the 66th annual convocation held on 23rd February 2021	: 442

1.4 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 an excellent collection of over 4 lakh print documents along with 76 print journals, 1,32,000+ e-books (mostly from Springer Link, CRCNetBase etc) and full-text access to 27,000 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 published during the years 1850 to 2019 and CRCnetBASE e-books published during the years 2004 to 2019.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 www.library.iitkgp.ernet.in to provide various library services to its users. Central Library is ISO 9001:2015 certified.

1.5 Technology Students Gymkhana

The concept of the Technology Students' Gymkhana as a forum of Sports and Games, Social and Cultural and Technology 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 two stadia, namely, Jnan Ghosh stadium and Tata Sports Complex. Besides these, there are also floodlit Basketball, Volleyball 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.

1.6 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 unit 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. An extension counter of Syndicate Bank is situated on the first floor of the Institute main building. A branch of Punjab National Bank is situated in the Tech. Market. In addition, an Axis Bank ATM is available inside the Gymkhana premises. Post Office is located close to the State Bank 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.

1.7 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 Club, Fine Arts Club, Publicity Club, Music Club, Yoga Club, Film Society, Dramatics Society, Aquatics Society, Astronomy Club 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.

1.8 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://noticeboard.iitkgp.ernet.in/hospi.htm.

1.9 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 wellbeing of the student community. Full-time clinical psychologists 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.

1.10 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.

1.11 Joint M.Tech./MCP Programme of IIT Kharagpur

IIT Kharagpur invites applications for the Joint Masters and Ph.D. programme in Engineering and City Planning for the admission year 2021-2022. This programme encourages bright and motivated students to enrol themselves for Ph.D after completion of first year of M.Tech/MCP 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 programme.**

Students selected for Ph.D will have to complete the two year academic requirements of M.Tech/MCP programme before enrolment for Ph.D. For these students, the M.Tech/MCP 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 Aerospace Engineering. Active research program, leading to MS and PhD degrees also exists. The Department has a large number of 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, 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. 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. Major Propulsion Laboratory facilities include Axial Flow Fan Test Setup, Centrifugal Fan Test Unit, 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. 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 Department offers M. Tech Degree in:

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 - Aquaculture 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.

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.

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 Costal Engineering, Design of Aquacultural Facilities and Equipment, Planning and Design of Aquacultural Projects, Water Quality Management Practices, Principle and Fishing Technology, Advanced Aquaculture Technology, Computational Techniques in Fisheries, Water Resources System Analysis, Processing and Preservation of Aquacultural Products, Advanced Fishing Technology, Unit Operations in Aquacultural Products' Processing, and Transfer Processes in Food Engineering.

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.

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.

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 a postgraduate course in Master of 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 the second year 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. The Department offers following specialization:

AR - City Planning

Course Content:

|textbfThe Core Courses are: Planning Theory and Process, Statistical Techniques and Computer Programming, Transportation Planning and Traffic Engineering, Planning Legislation and Professional Practice, Development Management and Finance, Planning Workshop I and II (including Two-week field study in each).

Depending on their interests, the students are required to take up three Elective Courses in the first and second semesters each. The electives are grouped as follows:

Elective – I: Housing and Community Planning, Housing Policies and Programmes, District and Rural Area Planning;

Elective – II: Social Aspects of Human Settlements, Dynamics of Settlement Systems, Regional Development and Planning;

Elective – III: Utilities and Services Planning, Water Resources Economics, Development of Human Resources, Disaster Management;

Elective – IV: Remote Sensing and GIS in Planning, Systems Modelling and Analysis, Planning Informatics;

Elective - V: Quantitative Methods in Planning, Regional Analysis and Programming, Environmental Planning, Metropolitan Planning;

Elective – VI: Tourism and Recreational Planning, Urban Conservation Studies, Urban Design, Landscape Planning;

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. A comprehensive viva-voce is conducted to review their knowledge base at the end of the stages of learning. 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.

2.4 DEPARTMENT OF BIOTECHNOLOGY

Kharagpur initiated its Biotechnology program in 1986 through the introduction of a M.Tech Course 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 introduction of an undergraduate course in Biotechnology and Biochemical Engineering in 1994, and an independent Department in 1999. The Department currently offers B.Tech (Hons.), Integrated B. Tech-M.Tech, Integrated M. Tech-PhD and PhD programs as well as opportunities for post-doctoral research. The M. Tech program has a conglomerated yet balanced theoretical exposure to Modern Biological Sciences and Bioprocess Engineering, as well as well-structured laboratory courses. Oratory and presentation skills as well as knowledge of recent research advances is provided 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 Cell and Molecular Biology, Structural Biology (Macromolecular crystallography), Plant Biotechnology, Biochemistry, Fermentation, Biochemical Engineering, Downstream Processing, Bioinformatics, r-DNA Technology, Bio-separation, Microbiology and Immunology, Molecular Genetics, Protein Chemistry, Proteomics, Genomics. The faculty has strong interaction with reputed Institutions nationally and internationally. The achievements in Research outcomes, Industry-Institute collaborative research, 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: Bioseparation Technology, Immunotechnology, Biotechnology of Plant Metabolites, Recombinant DNA Technology.

Electives: Aspects of Biochemical Engineering, Process modelling and simulation, Secondary Metabolism in Plants and Microbes, Protein Engineering, Immobilization Technology, Biophysics and Instrumentation in Biology, Quality control in Biotechnology, Bioprocess Plant and Equipment Design, Crop Breeding and Biotechnological Application, Transgenic Technology, Statistical Techniques in Computer Programming, Data Warehousing and Data Mining, Object oriented programming, Industrial relations, Total Quality Management, Development of human resources, Interpersonal communication.

Lecture classes are supported by well planned laboratory experiments in Animal Cell culture, Immunotechnology, Bioseparation and Bioprocess Technology, Plant Biotechnology and Recombinant DNA Technology.

Areas of Research:
Bioprospecting healthcare metabolites and nutraceuticals from plants and microbes, Production and analysis of transgenic plants; Hydrogen production by bacterial fermentation; Bioprocess & Biopoduct Development; Bioprocess modelling & optimization; Microbial & microalgalbiorefinery; Biofuels and value added products; Biological carbon capture and waste valorization; Microbial fuel cell; Marine biotechnology; Biomaterials for tissue engineering; Characterization of virus infecting tasar silk worms; Gene expression in prokaryotic and & eukaryotic systems; Lectin & mushroom glucans as immunomodulators; Bio-microfluidics for single cell Biology and multiplex diagnostic development, Proteomics and protein-protein interaction; Monoclonal antibody production; Recombinant protein production in plant, animal and microbial cells; 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 Entamoebahistolytica and E. invadens. Study of signal transduction in trophozoite and encysting Entamoeba. Systems biology encompassingstudy 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=PGsplCode=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 and we have continued to do well by all accounts. The most recent QS World University Ranking (2020) places our department at the joint 3rd position in India. Globally we are ranked in the top 150. We aim to move up into the top 25 in Asia, and in the top 100 globally in the next couple of years.

Our department is home to 26 faculty members, 120+ doctoral students and postdoctoral fellows, with research covering diverse areas of basic and applied chemical engineering, as well as those at the interfaces with other areas of science and engineering. We have an estimated 445 undergraduate students (which include 188 dual degree students), and are graduating about 100 of them per year. We also have about 147 regular M.Tech. students, which include student from outside India. About half of the M.Tech students graduate every year.

A glimpse at our faculty profile on the departmental website (http://iitkgp.ac.in/department/CH) reveals the diversity of research being undertaken by them. They range from the nano and molecular

scales to the pilot plant scales, in areas as varied as: 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; Coal Science and Engineering; Petroleum Production Engineering; 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; Multiphase Flow.

Our department houses state-of-the-art computing facilities as well as instruments such as 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 Larsen & Toubro, SAIL, Tata Steel, DRDO, AERB, ONGC, BHEL, Essar Steel, Indian Oil Corporation, CMPDE, 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, etc., are examples of some of the industrial projects being carried out by our department. The National Biogas project and the removal of hazardous impurities such as arsenic from drinking water at an industrial scale were undertaken to serve rural India. Our department has filed for patents, several of which are granted, and some of the technologies have been commercialized through technology transfer. Our department runs Executive M.Tech Program in collaboration with leading institute in India, and also conducts short-term courses for industry professionals.

Our department has established international collaborations through the signing of Memorandum of Understanding 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, Euromembrane, ISCRE, European Congress of Chemical Engineering, etc. Starting this year, our department now recruits international students in its post-graduate programs, and has hosted several international students as summer interns over the past few years. Every autumn, our department invites a globally renowned chemical engineer to deliver the Annual MN Rao Memorial Lecture – named after one of its most illustrious faculty and the first Indian Head who helped build this department at its inception.

We endeavor to create a truly international department that offers the right balance between basic and applied research, engages in collaboration with other Indian and international institutes, and hones our students with the core competency they would need to excel in their future chemical engineering careers in industry and academia.

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: Optimization Techniques in Process Design, Process Modelling and Simulation, Industrial Pollution Control, Petroleum Refinery Engineering, Advanced Thermodynamics, Multiphase Flow, Reservoir Engineering, Green Technology, Transport Processes in Physiological Systems, 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, Real Time Intelligent Process Systems, Novel Separation Processes, Petrochemical Technology, Chemical Reactor Analysis, Combustion Engineering , Mineral Beneficiation, Reactor Stability and

Control, Computer Process Control, Fluidization Engineering, Project Engineering and Management, Hazard Analysis and Risk Management in Chemical Industry, Flow of Complex Mixtures, Manufacturing and Characterization of Polymer Matrix Composites, Storage and Handling of Materials, Hazardous Waste Treatment and Management. Areas of Research: Transport Processes, Reaction Kinetics, Process Modelling and Simulation, Molecular Simulation, Advanced Thermodynamics, Nonlinear Control, Membrane Technology, Environmental Engineering, Micro-scale Heat Exchange, Reaction Engineering and Chemical Process Development, Petroleum Refining and Petrochemicals, Coal Processing, Particle Technology and Mineral Beneficiation, Bioprocess Engineering and Biofuels, Surface science and Nanotechnology, Modeling of Physiological systems.

Areas of Research: Transport Processes, Reaction Kinetics, Process Modelling and Simulation, Molecular Simulation, Nonlinear Control, Membrane Technology, Environmental Engineering, Micro-scale Heat Exchange, Reaction Engineering and Chemical Process Development, Petroleum Refining and Petrochemicals, Coal Processing, Particle Technology and Mineral Beneficiation, Bioprocess Engineering and Biofuels, Surface science and Nanotechnology, Modeling of Physiological systems.

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 MTech 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 MTech programmes in the following SIX 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 Viscoelasticity; 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, Complex and Social Networks, Data and Web Mining, Formal Methods, Cryptography and Security, 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 cote theory courses and two rigorous core lab courses to lay strong foundations to 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.

The course contents and other details for the M.Tech specialization are given below.:

CS - Computer Science and Engineering

Course Contents: Algorithm Design and Analysis, Foundations of Computing Science, High Performance Computer Architecture, Computing Lab I, Computing Lab II, Seminar I and II, Comprehensive Viva Voce, Project, 7 Elective courses

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

Cryptography and Network Security, Hardware Security, Foundations of Cryptography

Advanced Graph Theory, Computational Complexity, Computational Number Theory, Logic for Computer Science, Computational Geometry, Parallel and Distributed Algorithms, Selected Topics in Algorithms, Approximate and Randomized Algorithms

Distributed Systems, Database Engineering, Object Oriented Systems, Internet Protocols and Applications, Software Engineering, Real Time Systems, Fault Tolerant Systems, Performance Evaluation and Reliability of Information Systems, Embedded Systems, Smartphone Computing and Applications, Ubiquitous Computing

Testing and Verification of Circuits, VLSI System Design, Advances in Digital and Mixed Signal Testing, CAD for VLSI Design, Low Power Circuits and Systems

Algorithms for Bioinformatics, Computational Biophysics: Algorithms to Applications.

Areas of Research: Algorithms, Artificial Intelligence and Knowledge based systems, Computer Systems and Networking, Cryptography, Security, Computer Vision and Image Processing, Computer Graphics and Computational Geometry, Formal Systems, Embedded Systems, Software Engineering, Machine Learning, Natural Language Processing, Complex Networks, Social Computing.

2.8 DEPARTMENT OF ELECTRICAL ENGINEERING

The first postgraduate programme to be started in the department was on “Electrical Machines” in the year 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 specialization on “Power

Systems" was introduced in 1965, that has now been redesignated as "Power and Energy Systems" since 2010. The program on 'Instrumentation' which started in 1972 has been revised in 2012 and renamed as 'Instrumentation and Signal Processing'. Thus, the Department offers the following areas of specialization for the M. Tech degree:

EE1 - Machine Drives and Power Electronics (MDPE)

EE2 - Control System Engineering (CSE)

EE3 - Power and Energy Systems (PES)

EE4 - Instrumentation and Signal Processing (ISP)

Course Contents:

Core Courses:

EE1: The subjects presently offered are: Switched Mode Power Conversion, Machine Analysis, Electric Drive Systems, Advanced Machine Drives, Advanced Power Electronic Converters, Power Electronics and Machines Laboratory and Machine Drives Laboratory.

EE2: The subjects presently offered are: Control Theory, Estimation of Signals and Systems, Optimal Control and Non-linear Control and Control Systems Laboratory.

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

EE4: The subjects offered are: Analog Signal Processing, Programmable and Embedded System, Statistical Signal Processing, Mixed Signal Circuits and Systems on Chip, Advanced Sensing Techniques, Embedded Systems Laboratory, Real-Time Signal Processing Laboratory and Instrumentation Laboratory.

In addition to the "core" subjects mentioned against each specialization above, students are required to choose five "elective" subjects (one of which may be a HSS / Management subject) in their special areas of interest. Practical oriented laboratory exercises are carried out in the first two semesters. Three hours per week are earmarked for "seminar" in the first two semesters followed by a comprehensive viva voce at the end of the second semester. A project dissertation on a relevant problem under the supervision of a faculty member and / or persons from industry follows the course work of two semesters.

The Department offers a large number of electives for specialization in various areas. Some of the electives are: Electric Vehicles, Special Electrical Machines, Wind Energy, Nonconventional Electrical Energy Systems, Intelligent Control, Robust Control, Digital Control, Artificial Intelligence applications to Power System, High Voltage and Insulation Engineering, Industrial Applications of High Voltage Engineering, Digital Signal Processing, Computational Methods and Algorithms in Signal Processing, Data Communication Systems, Digital Image Processing, Biomedical Signal Processing, Advanced Digital Signal Processing, Industrial Automation and Control, Process Monitoring and Fault Diagnostics, Industrial Instrumentation, 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, Reliability Engineering Centre 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.

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 Signal Processing: Sensors Development, Electrochemical sensor, Optoelectronic sensor, MEMS and Mixed Signal VLSI, Embedded Systems, Estimation& Detection of Signals& Systems, Signal& Image Processing, Computer Vision and Machine Learning, Medical Signal processing and Informatics.

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 - Micro Electronics and VLSI Design

EC3 - RF and Microwave Engineering

EC4 - Telecommunication Systems Engineering

EC5 - Visual Information and Embedded Systems Engineering

Course Content:

Core Course:

EC2: Solid State Circuits, VLSI technology and process modelling, VLSI CAD, VLSI circuits and systems, and five number of elective subjects to be chosen from core subjects of EC1, EC3, EC4, EC5, or elective list. It also includes one HSS elective and three number of laboratory subjects distributed over two semesters and a seminar each in the two semesters

EC3: Electromagnetic engineering, Antenna theory and practice, Analytical and computational techniques in electromagnetics, RF and microwave integrated circuits, and five number of elective subjects to be chosen from core subjects of EC1, EC2, EC4, EC5, or elective list. It also includes one HSS elective and three number of laboratory subjects distributed over two semesters and a seminar each in the two semesters.

EC4: Modern digital communication techniques, Digital voice and picture communication, Mobile Communication and Fading, Telecommunication switching and networks, and five number of elective subjects to be chosen from core subjects of EC1, EC2, EC3, EC5, or elective list. It also includes one HSS elective and three number of laboratory subjects distributed over two semesters and a seminar each in the two semesters.

EC5: Digital Image Processing, Embedded systems Design, Pattern Recognition and Image understanding, Computer communication and Networks and five number of elective subjects to be chosen from core subjects of EC1, EC2, EC3, EC4, or elective list. It also includes one HSS elective and three number of laboratory subjects distributed over two semesters and a seminar each in the two semesters.

Electives: Neural networks and applications, Estimation and prediction in computer control, Machine intelligence and expert systems, Computer visualization and solid engineering and automation, Adaptive system and signal processing, Parallel and distributed processing, Design and analysis of algorithms, Multimedia systems and applications, Mobile computing, Fuzzy set theory and application, Digital system testing and testable design, Formal languages and automata theory, Performance evaluation of computer systems and networks, Relational and object oriented database design, Optical signal processing, Fibre optic sensors, Nonlinear optics, Laser Technology, Lightwave networks, Compound semiconductor and applications, Architectural design of ICs, Hybrid Microcircuits Technology, Optoelectronic and display devices, Microwave semiconductor devices, Digital signal processing and applications, Technology CAD, MEMS and Microsystems, Nanoelectronics devices engineering, Superconducting devices and application, Bioelectronics, EMI and EMC techniques, Microwave remote sensing and radar cross section, Phased array antennas, Microwave measurement Telecommunication systems modelling simulation and software, Mobile communications and fading, Secure communications, Telematics and informatics.

Areas of Research:
Thrust Areas of the Department:

1. Silicon Heterostructures
2. Nanoelectronics
3. MEMS
4. Wireless Communication
5. Optical Communication
6. Sensor Networks
7. EMI / EMC
8. Smart Antennas
9. Image and Video Processing
10. Machine Intelligence Systems
11. Integrated Optics

12. CAD and VLSI Technology
13. Wireless Networks
14. Optical Networks
15. Computational Electromagnetics
16. RF System Design
17. Digital Signal Processing
18. Multimedia Processing
19. Speech Recognition
20. Embedded Systems
21. Biomedical Signal Processing

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

Communication Engineering: Digital Modulation Techniques, Digitization of Speech; Bandwidth Compression of Speech Signals; Picture Coding; Spread Spectrum Techniques; Speech Frequency, Multimedia Encryption, Satellite Communication, Mobile Communication, Computer Communication.

Visual Information and Embedded Systems: Computer Vision, Computer Networks, Microcontrollers and embedded systems, Fuzzy Techniques and Pattern Recognition, Machine Learning, Image and Video Processing, Video and Multimedia Coding, Gesture Recognition, Real-time Architectures for Image and Video Processing, Video Transcoding, Multimedia Networking, Video Indexing and Retrieval, Biomedical Image Processing.

Microwave, Millimeterwave and Antenna Engineering: 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.

Microelectronics: CVD for Silox and Polysilicon, Plasma Processing and Ion-beam, High Speed Address Multipliers, Gate Array, Process Modelling, Special purpose Signal Processors and their application in Biomedical Instrumentation, CAD of LSI/VLSI Systems, Device Modelling, MEMS.

Fibre Optics and Lightwave Engineering: WDM-based Backbone and Access Networks, IP-over-WDM, Optical Bursth Switching, Nonlinear Phenomena in Optical Fibres, Integrated Optics, Coherent Optical Communication.

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 inquality 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-BandSeismological 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 four 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, (iii) Dual Degree - Quality Engineering Design and Manufacturing, (iv) Dual Degree - B.Tech in Mfg. Science & Engg. And M.Tech in Industrial Engineering and Management, and (v) M.Tech in Industrial Engineering and Management. 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.

IM - Industrial Engineering and Management

Course Content: For the 2-year MTech Program, the compulsory subjects include (i) Decision Modelling, (ii) Work System Design, (iii) Production Planning and Inventory Control, (iv) Advanced Decision Modelling, and (v) Systems Modelling and Analysis. The compulsory laboratories are (i) Computational Laboratory, (ii) Work Design Laboratory, and (iii) Information Systems Project. In addition, each student has to select five 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, 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.

Areas of Research: 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.

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 from the inception, the department had a strong group involving areas like Fluid Mechanics, Variational methods etc. 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 Wipro NetPower Server and Dell PowerEdge R710 two blade servers for high end computational needs of students and research scholars. 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 desktops. All these systems are connected to other computing facilities in the Institute through LAN of the institute. For further information 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, Bio-Mechanics, 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 Applied Mechanics, Thermal Science and Engineering, Manufacturing Science and Engineering.

M.Tech courses are offered in 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 specialisation.

The M.Tech courses offered are:

ME1 - Manufacturing Science and Engineering

ME2 - Thermal Science and 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., noise and Vibration 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, Industrial fluid power and control, Mechanical Drives and Gear Engineering.

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 oC) 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, alloysbased 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 i) Geomechanics for Mineral and Energy Resources and ii) Safety, Health and Environment.:

MI1 - Safety, Health and Environment

MI2 - Geomechanics for Mineral and Energy Resources

MI1 (Safety, Health and Environment): 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, healthand 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-spatial and Geo-imaging; Rescue Robotics, Facility location; Capacity Utilization; Investment and Financing Strategic Planning.

MI2 (Geomechanics for Mineral and Energy Resources): 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 Capacity, 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.

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 B.Tech 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 R&D 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

NA - 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 Mechanics, 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: Coastal 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-year Integrated M.Sc. 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 in consultation with Departments of Electronics and Communication Engineering, Civil Engineering, Metallurgical and Materials Engineering, Chemistry, and Materials Science Centre and Centre for Theoretical Physics. Several related subjects from these Department and Centres have also been included in the curriculum.

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, Surface Science, 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:

Structure-property correlation of amorphous and crystalline materials, electrical transport, thermal, magnetic, and optical properties of materials. Phase transition phenomena in solids. Preparation of nano-materials, semiconductor thin films, disordered solids, ferroelectric materials, polymer composites etc. X-ray diffraction, Raman spectroscopy, Laser spectroscopy, Impedance spectroscopy, and Crystal growth techniques. Device studies on photonic crystals, optical fibres, spintronics, fuels cells, solar cells, energy storage, memories etc.

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.

AT - Embedded Controls and Software

Course Overview: Our world is increasingly becoming automated, through the ubiquitous presence and coordinated involvement of embedded systems, controls and software. From medical devices to transportation (ships, railways, cars, aerospace, etc) or security systems to process industries, which affect our daily lives, rapid automation of these systems is taking place thanks to the incorporation and advancement of embedded systems, controls and software. Hence, it is evident that the requirements of the global industry are clearly shifting towards a large demand in advanced and skilled workforce who have the combined expertise in these areas, resulting in a more complex and multidisciplinary field.Hence by studying such courses about the integrated embedded systems with controls and software, students will be equipped to solve the software challenges along with the embedded design to execute the control algorithm, prevalent in the practical systems.

Placement: Due to huge industry interest, this course is getting attention with 100% placement continuously for last few years and the students are getting placed in the companies like Honeywell Technology Solutions, Mercedes Benz, Eaton Technologies, NetApp, TVS Motors etc.

Course Content:

Core Courses: Embedded Control Systems, Embedded Software Design & Validation, Software Design and Validation Laboratory, Embedded Controls Laboratory, Embedded Applications Laboratory, Seminar, Comprehensive Viva-Voce.

Elective Courses: Embedded Systems, Principles of Automotive Dynamics and Control, Security aware CPS and IoT design Logics for Computer Science, Testing and Verification of Circuits, Cryptography and Network Security, Artificial Intelligence, Advanced Graph Theory, VLSI System Design, Object-Oriented Systems, Control Theory, Estimation of Signals and Systems, Industrial Instrumentation, Digital Signal Processing, Intelligent Control, Digital Control, Modeling and Simulation, Process Monitoring and Fault Diagnosis, Embedded Systems Design, Modelling and Simulation of Dynamic Syst., Machinery Fault Diagnostics & Signal Proc., Automatic Control, Reliability Analysis & Prediction, Communication Systems and Networking, Embedded Low Power Systems, MEMS and Biosensors, Stochastic Process Simulation, MEMS and Applications, Wireless Adhoc and Sensor Networks, Intelligent Machines and Systems, High Performance Computer Architecture, Real-Time Systems, Distributed Systems, Advanced Microprocessor Based Systems, Intelligent Systems, Advances in Operating Systems Design, Machine Learning, Fault Tolerant Systems, CAD for VLSI Design, Advances in Digital and Mixed Signal Testing, Advanced Control Theory, Adaptive and Learning Control, Advanced Estimation Theory , Discrete Event Systems, Real Time Systems, Advanced Digital Signal Processing, Optimal Control, Non-Linear Control, Adaptive Systems and Signal Processing, Mechatronics, Computer Controls of Machines and Processes, Robotics , Internet and Web based Technologies, Information and System Security, Software Reliability, Fault Diagnosis and Predictive Maintenance, Computer Process Control, Real Time Intelligent Process

Systems, Process Dynamics and Control, MEMS and Microsystems Technology, Signal Processing / Telecommunication, Fluidic Instrumentation and Control, Electric Vehicles, Analog Signal Processing, Power System Dynamics and Control, Industrial Automation and Control, Biomedical System Engg. and Automation etc.

Areas of Research: Current areas of research related to the Masters' program in ECSat ATDC include Embedded Controls and Software,Controls, energy management and diagnostics of electrified vehicles, security analysis of modern IoT framework along with 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, DST etc.

2.19 CENTRE FOR OCEANS, RIVERS, ATMOSPHERE & LAND SCIENCES

The 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 training in Earth System Sciences and Technology. The vision of the Centre is to become a world class educational and research hub for the development of high quality manpower in the area of Oceanography, Atmospheric Science, Land System, River Science and related physical, biological, and societal systems. It will also act 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 Systems Science such as climate changes, Ocean State simulation, Tsunamis, Cyclones and so on.

At present the Centre is offering a two year Postgraduate Program i.e. Master of Technology in Earth System Science and Technology. Meritorious students working in the project are allowed for MS. The Centre is also having Ph.D program. It is coincident that the start of the master's program by CORAL almost coincides with the establishment of Ministry of Earth Sciences by Government of India. The Centre is having Computing and Visualization Laboratory for integration of numerical models and visualization of these products. The Centre is also having a national atmospheric observational tower facility.

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 Oceanography, Atmospheric Science, Land System, River Science and related physical, biological, and societal systems. 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 the other M. Tech Programmes of the institute providing ample flexibility to the students to learn as per the course and the interest. The core subjects include; Advance Meteorology, Dynamics of Fluvial Systems, Ocean Dynamics, Global Tectonics and Climate with electives covering a set of vast topics from Advanced Instrumentation Techniques, Satellite Oceanography, Ocean Colour and Applications, Ocean Circulation and Wave Modelling, Marine Biotechnology, Polar Science, Modelling of Extreme Events, Carbon Cycle and Global Climate Change, Climate Modelling, Climate Risk Assessment in Agriculture, Land System Studies, Neural Networks and Applications, Advanced Computational Hydraulics, Groundwater Modelling and Simulation, Integrated Watershed Management, Aqueous Environmental Geochemistry, Geo-informatics and Data Analysis to Environmental Hazard Management etc. The centre is also offering laboratory courses on Atmospheric and Hydrological Modelling, Ocean and Storm Surge Modelling and Data Analysis and GIS Applications.

Areas of Research: The centre is involved in frontier research in oceanographic and atmospheric observational and modelling. In oceanography, the areas of present research activities include numerical modelling of Bay of Bengal and Indian Ocean, wave modelling and ocean circulation. In atmospheric research, the present focus is on the observations and modelling studies of severe thunderstorms. Besides,

the centre is also involved in 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 observational modeling studies of 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. In view of India's active research in Antarctica, the Centre is also focusing on the remote sensing of sea-ice and southern ocean in relation to climate studies.

2.20 CRYOGENIC ENGINEERING CENTRE

Cryogenic Engineering Centre was established in 1976 on the recommendation of Nayudumma Committee for the advancement of cryogenics and cryogenic engineering. The Centre aims at generating expert manpower in this advanced field of science and technology through teaching and research. The Cryogenic Engineering is a multi-disciplinary area, accordingly the academic curriculum has inputs from major disciplines, like, Mechanical Engineering, Physics, Chemical Engineering, Electrical and Instrumentation Engineering. This 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.

The Centre offers several courses related to cryogenic engineering and applied superconductivity at both undergraduate and postgraduate levels. Research and development activities are carried out through its postgraduate and doctoral programmes as well as through interdepartmental undergraduate and postgraduate collaborative projects. The Centre is also active in Continuing Education Programme of the Institute by conducting short term courses and workshops in specialised areas to train engineers from industries, faculty from academic institutions and scientists from R&D organisations.

The Centre receives sponsored and consultancy projects from various government agencies and industries. Some of these include DST, BARC, ISRO, ME (earlier MHRD), CSIR, ONGC, BHEL etc DST has funded the Centre to establish liquid-helium-free superconducting magnet-based research facility in the Centre. Research facilities and cryogen-production facilities were modernized through bi-nation collaboration under Indo-FRG Cooperation in cryogenic engineering.

Alumni of the Centre serve different national and international laboratories, IITs, NIts, and cryogenic and allied industries.

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.

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.

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.

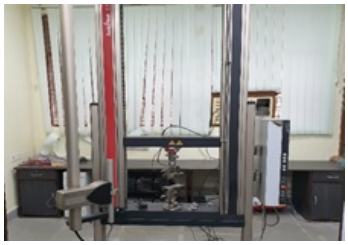
The Centre has an active M.Tech Programme in Materials Science since 1980. The annual intake strength is 25 students. The programme is inter-disciplinary and draws on students from physics, chemistry, materials science and engineering, polymer chemistry, etc. The programme is tailored to have mainly 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. It is now starting a new thin specialization in Materials Science for B. Tech students of all disciplines.

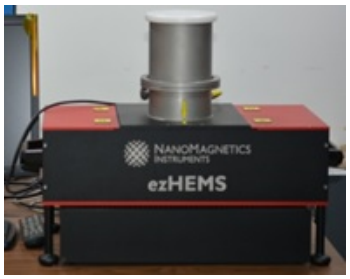
The major research facilities available in the Centre include a Keithley 4200-SCS Parameter Analyzer, Thermal transport measurement facilities (Hot Disk TP2500S), Photoluminescence (PL) unit (PTI USA), Zeiss FESEM, Tescan Vega 2 SEM, Quantachrome BET, Panalytical Empyrean XRD, Class AAA Solar Simulator (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.

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

Keithley 4200-SCS Parameter Analyzer

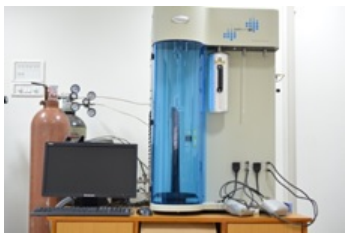


Zwick UTM



Hall measurement

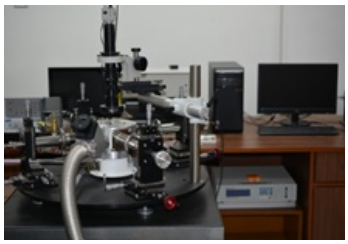
Zeiss FESEM



BET

Panalytical Empyrean XRD

Solar Simulator



Cryo-Cooled Electrical Probe Station

DMA

DSC and TGA

Seebeck Coefficient Measurement

UV-Vis Spectrophotometer

The Centre offers an M. Tech Degree in Materials Science and Engineering

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 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

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 role 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 upgrading the Reliability Engineering Centre (established in 1983). It is the first and unique School of excellence in India offering Masters' and research programs in the areas of Quality and Reliability Engineering. The conventional engineering branches mainly focus on design of systems for certain specific functional requirements. But in Quality and Reliability Engineering, students are trained on how to design, predict, estimate, and demonstrate performance of a product throughout its mission life for failure free operation, which is also safe and easy to maintain deriving maximum benefits. In short, 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 etc. as well.

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 associated areas. All our students have been placed well in various organizations and the feedbacks we receive from them have been very encouraging.Students of the School are well placed in MNC's and reputed organizations like BARC, Bloom Energy, Crompton & Greaves, DRDO, Cummins India, Oceaneering India, Eaton, Philips India, Entity Solutions, GE, GM, Goodrich, HCL, Honeywell, IBM, INFOSYS, ISRO, LM Glass Fiber, MarutiUdhyog, NPCIL, Mahindra Tech, TATA Steel, TCS, Time Tooth, WIPRO, TVS, Bosch and the list continues.

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. Infact, 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 such as M.Tech., MS and PhD. 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. Short term MDP and EDPcourses for working professionals in industry and R&D 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.

RE - Quality and Reliability Engineering

Course Content: Reliability Engineering, Quality Control and Analysis, Advanced Reliability Engineering, Robust Design for Quality, Reliability Demonstration Laboratory, Quality Engineering Laboratory and Reliability Testing Laboratory are the core subjects. Besides this, the School also offers a number of elective subjects including Statistical Methods in Reliability, Probabilistic Risk Assessment, Statistical Process Control, Environmental Testing and Reliability Demonstration, Failure Data Organization and Analysis, Performance Engineering for Sustainability, Reliability Centred Maintenance, Maintenance Management, Fault Diagnosis and Predictive Management, Safety Engineering, Human Reliability, Software Reliability, Reliability Estimation and Life Testing, TQM, Software Quality Assurance, Reliability Management, etc..To make the course more balanced and interdisciplinary, a number of other department elective subjects are included in the curriculum. Students are encouraged to take an elective subject in the management area as well. Students are also encouraged to take live industrial problems for their thesis work during the second year.

Areas of Research: The School is actively engaged in research in the areas of: Failure mechanism and failure analysis of electronic, electrical and mechanical component/devices, Reliability prediction and testing of components and devices, Hazard and safety analysis of systems and devices, condition monitoring and fault diagnosis of machines and plants, Design of cost optimal and performance based maintenance policies, reliability centred maintenance, quality engineering, network reliability, power system reliability, software reliability, Probabilistic risk assessment,big data security and cloud service reliability.

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 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 2021-2022, It may be noted that this year the students of Wireless Communication and Networks specialization offered by GSSST have secured 100% placement in reputed companies.

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.

2.25 RANBIR & CHITRA GUPTA SCHOOL OF INFRASTRUCTURE DESIGN & MANAGEMENT

Infrastructure is recognized today as one of the most essential requirements for economic development of any country. Its importance has been increasingly appreciated by policy makers of different countries, including India which envisages a growth rate of nine percent during the eleventh plan period (2007-08 to 2011-12) for which about Rs. Two million Crores need to be invested in key infrastructure sectors during the eleventh plan period. Besides generating the necessary finances, it is very important to build necessary capacity to realize these ambitious targets. Large infrastructure projects require strong, interdisciplinary technical and management skills. It has therefore become imperative that Institutes bestowed with solid foundations in engineering, architecture, and management skills should initiate academic programmes to develop trained manpower in this upcoming area of infrastructure design and management.

Indian Institute of Technology Kharagpur has a vantage position with regard to its existing faculty and academic programmes in the areas of engineering, architecture and management. The institute, with its numerous academic departments, centers and schools with academic programmes in such wide ranging areas such as law, management, architecture and engineering, is in a uniquely advantageous position to contribute to the nation's goal of building world-class infrastructure.

The Ranbir and Chitra Gupta School of infrastructure Design and Management has been started by IIT Kharagpur in the year 2008. The school of Infrastructure Design and Management is the first such school to be set in the IIT system and also in the country.

The mission of the School is to prepare outstanding professionals capable of designing and delivering quality infrastructure projects efficiently and effectively with a comprehensive and fast-track approach.

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.

2.26 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 - Energy Science and Engineering

ore Subjects: Renewable Energy Resources, Thermodynamics, Fluid Mechanics, Energy Conservation and Waste Heat Recovery, Convective Heat and mass Transfer, Heat Transfer; Electric Power System-Analysis, Operation, Dynamics and control; Energy System Modelling along with Laboratories in all areas of Energy Science and Engineering

: Micro-scale Transport Processes, Process Modelling and Simulation, Petroleum Refinery Engineering, Advance Mathematical Techniques in Chemical Engineering, Power Electronic Converters and Machine Drives, Control Theory, Power System Protection, Digital Signal Processing, Digital Control, High Voltage and Insulation Engineering, Process Monitoring and Fault Diagnostics, Computational Methods in Thermal Engineering, Refrigeration Systems, Atmospheric Flow, Internal Combustion Engine, Thermal Systems Design, Conduction & Radiation Heat Transfer, Nuclear Power Generation and Safety, Reliability

Analysis and Prediction, Methods of Biomass and Bio Fuel Analysis, Fundamentals of Bio Energy, Chemical Reactor Analysis, Wind Energy, Industrial Automation and Control, Hydel Power and Wind Energy, Air Conditioning and Ventilation, Gas Turbines and Jet Propulsion, Safety & System Engineering, Fundamentals and Applications of GPS Technologies, Energy Materials, Waste to Wealth: Microbial intervention.

Lecture Classes are supported by well-planned laboratory experiments. Comprehensive viva, Seminars and Project are also part of the curriculum.

Areas of Research:
Fundamentals of Energy Sciences: Thermodynamics, Thermochemical and Electrochemical Reactions, Transport phenomena including heat and mass transfer and electrochemical phenomena, Solid-state phenomena including photo, thermal and electrical aspects, Bio-processes, Nano-sciences, Deep ocean processes, Gas and Fluid Dynamics, Nuclear sciences.

Energy Resources and Recovery: Traditional resources - Coal, Petroleum, Natural Gas; Others - Solar, Wind, Geothermal, Wave, Ocean-thermal, Biomass, Hydrogen, Gas from non-conventional sources - Gas Hydrates, Coal beds, Tar sands.

Energy Systems: Energy Conversion Systems for Oil, Gas, Coal, Solar, Wind, Biomass, Nuclear, Hydrogen, Ocean Waves, Waste. Power generation, distribution, transmission, access; Transportation Power Systems - IC Engine, Advanced Fuel Technology based combustion ignition, Electric, and Hybrid Systems. Embedded generation systems; Smart grids; Electrochemical systems; New age Fuel systems and process development; Hybrid and electrical systems; Battery & super-capacitors; Energy systems for marine, space and difficult terrains.

Other Aspects of Energy Science and Engineering: Energy Materials; Energy Storage & Transportation; Energy Efficient Devices & Systems; Energy Efficient Design of equipment, buildings and appliances; Sustainable Energy; Conservation; Recycling and Management: Environment and Climate Change; Computational Aspects; Energy Economics; Energy by-product (particularly carbon) recycling, capture, sequestration and storage; Rural and small scale energy research.

2.27 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.

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.

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; Telemedicine software supporting live medical teleconsultation.

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 in Biomedical Engineering:

SM - Biomedical Engineering

SM (Biomedical Engineering)

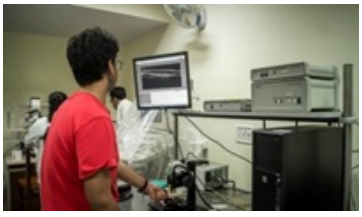
Course Content: Coursework covering different aspects of medical technology and research and includes six core and seven elective subjects that will help students to understand the fundamentals of living systems.

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, Comprehensive Viva-Voce, 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.

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



2.28 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, Biotech Engineering (only for PhD) and Mining Engineering (only for PhD).

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

WM - Water Engineering and Management

Programme Structure: The programme consists of foundation, specialization and integration phases. The foundation phase provides latest insights, context, and concepts in integrated water and environment management issues. In the specialization phase, the students choose to make in-depth study of water quantity and quality management in rural and urban areas or in basin scale. In the integration phase, the students are challenged to bring together and apply their cumulative learning process in the form of an M.Tech. thesis.

Core Courses: Environmental Hydrology and Hydraulics; Sectoral Water Demand and Distribution; Planning and Design of Water Engineering Facilities; Fate and Transport of Contaminant in Water; River Basin Planning and Management; Geo-informatics Laboratory; Water Engineering Laboratory.

Electives: Aquatic Ecology and Microbiology; Climate Impact on Water Resources; Geogenic-water Pollution and Control; Disaster Management; Wastewater Management; Environmental Chemistry and Microbiology; Free Surface Flow; Geohydraulics; Advanced Groundwater Hydrology; Remote sensing for Land and Water Resources; Industrial Pollution Control; Advanced Mathematical Techniques in Chemical Engineering; Statistical Technique and Computer Programming; Environmental Control in Mines; Rescue and Disaster Management; Water Economics and Governance; Flood Assessment and Management; Vadose Zone Hydrology; Advanced Water and Wastewater Treatment; Industrial Water Pollution Control; Environmental Statistics and Experimental Design; Advanced Computational Hydraulics; Environmental Impact Assessment; Environmental Sanitation; Water Resources System Analysis; On-farm Water Management; Modeling and Simulation for Agricultural Water Management; Environmental Pollution and Stress; Non-point Source Pollution and Management; Novel Separation Processes; Environmental Hydrogeology; Land System Studies; Probability and Stochastic Processes.

Areas of Research: Integrated water resources planning and management; River basin planning and management (considering the aspects of flood, drought or contaminant); Water and wastewater treatment; Surface and groundwater quality control; Conjunctive use of surface water and groundwater; Urban, rural, industrial water supply and distribution systems; Remote sensing and GIS application in water resources; Modelling of fate and transport of contaminants; Water governance and policy issues; Environmental impact assessment; Surface water and groundwater interaction; Water resources system analysis; Irrigation and drainage system planning, and Climate impact on water and environment.

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
4. NET qualified candidates with fellowship ONLY for MCP Programme

The admission will be based either 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. NET qualified applicants are also eligible for admission to MCP.
- 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 on or before October 31, 2021 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, 2021.
- 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 receive an assistantship of Rs. 12,400/- per month and Rs. 31,000/- per month after enrolment to Ph.D. programme. After completion of Ph.D. registration seminar, the students will receive an additional amount of Rs. 4,000/- per month for one year.
- 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.

Eligibility for NET Qualified Applicants

1. NET Qualified candidates with fellowship having M.A or M.Sc in Economics/Sociology/Geography and have studied mathematics/statistics at the higher secondary level or at the graduate level are eligible to be considered for selection to MCP-Ph.D Programme.
2. For applicant with Master's in Science subject should have 60% or above (55% marks or equivalent CGPA for Master's in Arts or Social Science subjects).

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.

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.

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	Specialisations offered and mode of selection
Figures 4.1 & 4.2	Eligibility for admission to different postgraduate programmes based on GATE Paper, applicant's academic background, seat distribution and mode of selection for the year 2021-22
4.9	Paper wise GATE Score cut-off for the Joint M.Tech/MCP-Ph.D Programme 2020-21.

- 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 2020-2021.

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/ from 23rd March 2021 to 20th April 2021. Candidates are required to register in the Common Offer Acceptance Portal (COAP) (https://coap.iitd.ac.in) 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 Important Dates

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.

Table 3.2: Calender of Events

Sl No	Action	Date
1	Opening of Website for Online Application	March 24 2021
2	Deadline for Submission of Online Application for Admission	April 20 2021
3	Issue of Call Letters for Interview (Applicable only for concerned courses)	To be announced later Please follow the JMP website for updates
4	Window for interviews	
5	Release of 1st offer including interviewed candidates through COAP (Common Offer Acceptance Portal)	
6	Last date of acceptance of 1st offer	
7	Release of 2nd offer through COAP	
8	Last date of acceptance of 2nd offer	
9	Release of 3rd offer through COAP	
10	Last date of acceptance of 3rd offer	
11	Release of 4th offer through COAP	
12	Last date of acceptance of 4th offer	
13	Release of 5th offer through COAP	
14	Last date of acceptance of 5th offer	
15	Last date for release of final offers	
16	Date of additional round after registration (if required)	
17	Admission to PG programs (as per academic calendar)	To be announced later

3.6 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 3.3
In addition to the above, hostel fee payable per semester is mentioned in table 3.4

Table 3.3: 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

Table 3.4: Hostel Fees payable per semester

Fee type	Amount (Rs)
Hostel overhead	800.00
Hostel Establishment Charge	16,640.00
Mess Advance	12,000.00

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.

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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	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	Ecology and Evolution	EY
11	Electronics and Communication Engineering	EC
12	Electrical Engineering	EE
13	Geology and Geophysics	GG
14	Instrumentation Engineering	IN
15	Mathematics	MA
16	Mechanical Engineering	ME
17	Mining Engineering	MN
18	Metallurgical Engineering	MT
19	Petroleum Engineering	PE
20	Physics	PH
21	Production and Industrial Engineering	PI
22	Statistics	ST
23	Textile Engineering and Fibre Science	TF

Table 4.2: GATE XE Section (Engineering Sciences) Papers

XE Section Paper	Code
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**
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 and Comprehension (Compulsory) (25 marks)	B1
Any ONE optional Section (60 marks)	
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
NET qualified candidates for MCP	G

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 Engineering & Materials Science	MES	Rubber and Plastic Technology Engineering	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 and Ocean Engineering	NO	Textile Engineering/ Fiber Science Engineering	TF
Nuclear Power Technology	NP	Textile Technology	TT
Nuclear Science and Engineering	NS	Transportation Engineering	TR
Ocean Engineering	OE	Upstream and Applied Petroleum Engineering	UP
Oil and Gas Informatics	OG	Water Resources Engineering	WR
Oil Technology	OT	Welding Technology	WT
Operational Research	OR	Any Discipline of Engineering not mentioned above	ZE*
Optics and Optoelectronics	OP	Any Discipline of Science not mentioned above	ZS*

*The JMP 2021 application of all those candidates choosing **ZE** or **ZS** will be considered for admission only when the concerned department accepts the actual qualifying discipline of the candidate as suitable for the chosen specialization.

Table 4.8: Specializations offered and mode of selection part - I

Department/Centre/School	Specialisation	Selection Mode*
Advanced Technology Development Centre	Embedded Systems and Software	Direct
Aerospace Engineering	Aerospace Engineering	Direct
Agricultural and Food Engineering	Farm Machinery and Power	Direct
	Land and Water Resources Engineering	Direct
	Food Process Engineering	Direct
	Agricultural Biotechnology	Direct
	Aquaculture Engineering	Direct
	Agricultural Systems and Management	Direct
Architecture and Regional Planning	City Planning	Direct
Biotechnology	Biotechnology and Biochemical Engineering	Direct
Chemical Engineering	Chemical Engineering	Direct
Civil Engineering	Hydraulic and Water Resources Engineering	Direct
	Transportation Engineering	Direct
	Environmental Engineering and Management	Direct
	Geotechnical Engineering	Direct
	Structural Engineering	Direct
Computer Science and Engineering	Computer Science and Engineering	Direct
Cryogenic Engineering	Cryogenic Engineering	Direct
Electronics and Electrical Communication Engineering	Microelectronics and VLSI Design	Direct
	RF and Microwave Engineering	Direct
	Telecommunication Systems Engineering	Direct
	Visual Information and Embedded Systems Engineering	Direct
Electrical Engineering	Machine Drives and Power Electronics	Direct
	Control System Engineering	Direct
	Power and Energy Systems	Direct
	Instrumentation and Signal Processing	Direct
Geology and Geophysics	Exploration Geosciences	Direct
G. S. Sanyal School of Telecommunications	Wireless Communications and Networks	Direct
Industrial and Systems Engineering	Industrial Engineering and Management	Direct
Infrastructure Design and Management	Infrastructure Design and Management	Direct
Mathematics	Computer Science and Data Processing	Direct
Materials Science	Materials Science and Engineering	Direct
Mechanical Engineering	Manufacturing Science and Engineering	Direct
	Thermal Science and Engineering	Direct
	Mechanical Systems Design	Direct
Medical Science and Technology	Biomedical Engineering	Direct
Metallurgical and Materials Engineering	Metallurgical and Materials Engineering	Direct
Mining Engineering	Geomechanics for Mineral and Energy Resources	Direct
	Safety, Health and Environment	Direct
Ocean Engineering and Naval Architecture	Ocean Engineering and Naval Architecture	Direct
Ocean, Rivers, Atmosphere and Land Sciences	Earth System Science and Technology	Direct
Physics	Functional Materials and Devices	Direct
Subir Chowdhury School of Quality and Reliability	Quality and Reliability Engineering	Direct
Rubber Technology	Rubber Technology	Direct
School of Energy Science and Engineering	Energy Science and Engineering	Direct
School of Water Resources	Water Engineering and Management	Direct

** **Direct** means Admission is based on GATE Score only.

Table 4.9: JMP 2020 Cut-Off Marks

Course Code	Major					Minor					PH
	GEN	EWS	OBC	SC	ST	GEN	EWS	OBC	SC	ST	
AE	630	-	586	381	321	-	-	-	579	-	-
AG1	644	549	446	407	407	-	-	-	-	-	-
AG2	601	558	472	286	342	-	-	-	-	-	-
AG3	623	567	420	307	333	732	-	-	-	316	-
AG4	598	-	573	238	218	538	-	406	-	-	-
AG6	489	480	376	242	-	456	-	-	-	-	-
AR	674	-	550	410	353	-	-	-	-	-	111
AT	777	-	709	559	430	-	-	-	-	-	321
BT	632	578	536	471	272	600	-	-	462	-	-
CE1	704	-	656	526	466	-	-	-	-	-	305
CE2	753	-	700	574	499	-	-	-	-	-	356
CE3	714	-	663	501	462	621	-	-	-	-	306
CE4	732	-	689	519	487	-	-	-	-	-	328
CE5	793	-	725	579	507	-	-	-	-	-	365
CH	581	573	513	342	294	-	-	-	-	-	270
CL	630	-	579	436	352	375	-	-	-	-	-
CR	713	705	666	461	315	-	-	-	-	-	-
CS	799	791	698	566	434	726	-	661	478	417	407
EC2	803	787	766	596	458	-	-	-	-	-	396
EC3	718	-	681	507	344	-	-	-	-	-	336
EC4	738	726	709	519	361	-	-	-	-	-	-
EC5	750	-	718	547	336	-	-	-	-	-	292
EE1	783	760	757	575	596	-	-	-	-	-	-
EE2	775	-	746	558	-	730	-	689	498	-	319
EE3	766	-	715	566	490	-	-	-	-	-	447
EE4	771	-	711	554	473	746	-	681	519	-	-
ES	754	-	713	563	488	-	-	-	-	-	277
ET	752	-	678	531	426	-	-	-	-	-	274
GG1	573	559	487	177	194	-	-	-	-	-	-
GS	738	-	701	543	409	-	-	-	-	-	344
ID	714	696	652	481	454	-	-	718	-	-	-
IM	819	-	760	-	-	771	-	722	549	-	344
MA	490	488	432	207	-	796	-	707	573	-	277
ME1	785	-	-	606	503	716	-	688	495	-	321
ME2	789	-	761	596	507	-	-	-	-	-	515
ME3	802	-	769	606	479	-	-	-	-	-	344
MN1	577	-	335	246	-	647	-	551	352	-	-
MN2	572	-	508	468	-	690	-	642	448	-	-
MS	392	-	352	-	-	421	-	393	283	-	-
MT	448	424	370	161	89	773	-	-	-	-	118
OE	680	-	642	472	341	480	-	-	-	-	-
PH1	402	-	357	203	-	-	-	-	130	-	-
RE	752	747	713	516	419	682	-	442	-	-	-
RR	805	-	676	554	-	-	-	-	-	-	317
RT	514	-	417	358	-	698	-	661	483	297	350
SM1	641	-	591	396	334	669	-	566	481	-	-
SM2	632	-	562	425	285	-	-	-	488	-	251
WM	536	-	424	264	260	-	-	-	-	-	275

Figure 4.1: Seat Matrix and Eligibility Criteria for JMP 2021

Course Code	Specialization	Major		Minor		Total Seats	Mode of Admission	Qualifying Degree	Qualifying Discipline
		Paper	Seats	Paper	Seats				
AE	Aerospace Engineering	AE	14	XE-B,CE,EE,ME	15	29	GATE Score Only	A	AE,AN,AV,CE,EE,EO,EP,IR,MAE,ME,MP,SC
AG1	Farm Machinery and Power	AG	19	ME	5	24	GATE Score Only	A	AG,ME
AG2	Land and Water Resources Engineering	AG	18	CE	4	22	GATE Score Only	A	AG, CE
AG3	Food Process Engineering	AG	26	CH,ME,XE-G	12	38	GATE Score Only	A	AG,CH,DT,FET,FPE,FT,ME
AG4	Agricultural Biotechnology	BT	12	XL-Q,XL-R,XL-S	13	25	GATE Score Only	A,C,D,E	AGS,BC,BT,GE,LB,MB
AG5	Aquaculture Engineering	AG	10	XE-B,CE,CH,XE-E	4	14	GATE Score Only		AG,CE,CH,OE
AG6	Agricultural Systems and Management	AG	18	XL-Q,XL-R,XL-S	6	24	GATE Score Only	A,C,D	AG,AGS,AI,BC,LB,MB
AR	City Planning	AR	52			52	GATE Score Only	A,B	AH,AR,CE,PA
AT	Embedded Controls and Software	CS,EC,EE,IN	14			14	GATE Score Only	A	AL,AP,CCE,CQ,CR,CS,CSE,CSS,CU,EA,EC,ECS,ED,EE,EEE,EI,EL,EN,EO,ETE,ICT,IN,IR,IS,IT,TE
BT	Biotechnology and Biochemical Engg.	BT	21	XL-Q,XL-R,XL-S,XL-T	8	29	GATE Score Only	A,C,D	BB,BC,BCH,BE,BI,BP,BPT,BS,BT,CB,CH,FB,GE,IB,LB,LS,LZ,MB
CE1	Hydraulic and Water Resources Engg.	CE	25			25	GATE Score Only	A	CE
CE2	Transportation Engineering	CE	25			25	GATE Score Only	A	CE
CE3	Environmental Engg. and Management	CE	15	CH,ES	7	22	GATE Score Only	A	CE
CE4	Geotechnical Engineering	CE	22			22	GATE Score Only	A	CE
CE5	Structural Engineering	CE	25			25	GATE Score Only	A	CE
CH	Chemical Engineering	CH	93			93	GATE Score Only	A	CH
CL	Earth System Science and Technology	PH,AG,MA,ME,AE,CE,GG	28	XE-B,XE-H,XE-E	10	38	GATE Score Only	A,D	AE,AG,AI,AS,CE,ES,EV,GG,MA,ME,NA,PH
CR	Cryogenic Engineering	AE,EE,ME	18	CH,PH	9	27	GATE Score Only	A,D	AN,CH,EE,EEE,EO,EP,ME,PH
CS	Computer Science and Engineering	CS	59	EC	25	84	GATE Score Only	A,D,F	AL,AP,CA,CCE,CQ,CR,CS,CSE,CSS,CU,EA,EC,ECS,ED,EE,EEE,EI,EL,EN,EO,ETE,ICT,IN,IR,IS,IT,MA,MK,SE,TE
EC2	Microelectronics and VLSI Design	EC	38			38	GATE Score Only	A	EC,EEE,EN,ETE,TE
EC3	RF and Microwave Engineering	EC	34			34	GATE Score Only	A	EC, ETE,TE
EC4	Telecommunication Systems Engg.	EC	34			34	GATE Score Only	A	EC, ETE,TE
EC5	Visual Information and Embedded Systems Engineering	EC	34			34	GATE Score Only	A	EC,ETE,TE
EE1	Machine Drives and Power Electronics	EE	22			22	GATE Score Only	A	EE,EEE,EY,PQ,PS,PW
EE2	Control System Engineering	EE,IN	13	EC	9	22	GATE Score Only	A	AC,AL,AP,EC,ECS,EE,EEE,EI,EO,ETE,IN,IR,RA,RE
EE3	Power and Energy Systems	EE	22			22	GATE Score Only	A	EE,EEE,EY,PQ,PS,PW
EE4	Instrumentation and Signal Processing	EE,IN	13	EC	9	22	GATE Score Only	A	AL,AP,EC,ECS,EE,EEE,EI,EO,ETE,IN,IR,RA,RD,RE

Figure 4.2: Seat Matrix and Eligibility Criteria for JMP 2021

Course Code	Specialization	Major		Minor		Total Seats	Mode of Admission	Qualifying Degree	Qualifying Discipline
		Paper	Seats	Paper	Seats				
GG1	Exploration Geosciences	GG	29			29	GATE Score Only	C,D	ES,EX,GG
GS	Wireless Communications and Networks	EC	12			12	GATE Score Only	A	CCE,CR,CS,CSE,CU,EA,EC,ECS,EE,EEE,EI,EL,EN,EO,ETE,ICT,IS,IT,OP,PV,RD,TE
ID	Infrastructure Design and management	AR, CE	30	CS,EE,IN,ME	10	40	GATE Score Only	A,B	AH,AR,CE,CF,CP,CS,CSE,CTE,EE,EEE,EI,GI,IK,IN,ME,PA
IM	Industrial Engineering & Management	ME,PI	14	CE,CH,CS,EC,AE,IN,MN,MT,EE,AG	18	32	GATE Score Only	A	AE,AG,AN,CCE,CE,CH,CR,CS,CSE,CSS,EC,EE,EEE,EI,EL,EN,ETE,ICT,IE,IM,IN,IP,IR,IS,IT,MAE,MC,MD,ME,MES,MF,MME,MN,MT,PI,PR,PS,PW
MA	Computer Science and Data Processing	MA	27	EC,EE,PH,ST	14	41	GATE Score Only	A,C, D	EC,EE,ETE,MA,PH,SS
ME1	Manufacturing Science and Engg.	ME	25	PI	7	32	GATE Score Only	A	IP,ME,MF,MT,PI,PR
ME2	Thermal Science and Engineering	ME	41			41	GATE Score Only	A	AE,AN,ME,PW
ME3	Mechanical Systems Design	ME	54			54	GATE Score Only	A	AE,AN,ME,MY
MN1	Geomechanics for Mineral and Energy Resources	MN	6	CE, PE	5	11	GATE Score Only	A	CE,CF,CP,CTE,ML,MN,PE
MN2	Safety, Health and Environment	MN	6	CH,EE,ME,PE,CE,PI	5	11	GATE Score Only	A	CE,CF,CH,CJ,CP,CTE,EE,EI,ET,GS,MD,ME,ML,MN,MW,PE,PPE,PW
MS	Materials Science and Engineering	CY,PH	28	XE-C,XE-F	10	38	GATE Score Only	A,C,D	CC,CG,CW,CY,CZ,EA,EP,IC,MS,NT,PC,PH,PL,PM,PN,PP,RP,RT,SA,SP
MT	Metallurgical and Materials Engineering	MT	52	XE-C, CH, ME, PH	15	67	GATE Score Only	A	CC,CEE,CG,CH,CJ,CW,CZ,EP,MC,MD,ME,MES,MF,MH,MI,ML,MME,MMS,MP,MS,MT,MY,PH,PR
OE	Ocean Engineering and Naval Architecture	AE, CE, ME	14	XE-B,XE-D, XE-E	11	25	GATE Score Only	A	AE,AN,CE,HOE,ME,MR,NA,NB,NF,NO,OE,SB
RE	Quality and Reliability Engineering	PI,MT,AE,CH,CS,EC,EE,IN,ME	21	XE-C, XE-D	4	25	GATE Score Only	A	AC,AD,AE,AL,AM,AN,AP,AT,AV,CCE,CH,CJ,CQ,CR,CS,CSE,CSS,CU,DM,EC,ECS,ED,EE,EEE,EI,EL,EN,EO,ETE,IE,IM,IN,IP,IR,IT,MC,MD,ME,MES,MV,MX,MY,PQ,TE
RT	Rubber Technology	XE-C,CY,XE-E,XE-F	18	TF,CH,ME,PI	11	29	GATE Score Only	A,C,D	CH,CJ,CY,IC,IP,LT,ME,MS,PC,PL,PM,PN,PP,RP,RT,TC,TF,TT
PH1	Functional Materials and Devices	PH	18	XE-C,MT	14	32	GATE Score Only	A,D	EC,EE,EEE,EN,EP,ME,MES,MH,MI,MME,MMS,MS,MT,NS,PH,SP
SM	Biomedical Engineering	BM,BT,IN,ST	12	EE,PH,CS,EC	7	19	GATE Score Only	A,D	AL,BM,BN,BP,BT,EC,EE,EI,IN,MP,MQ,PH
ES	Energy Science and Engineering	AE,AG,XE-B,BM,BT,XEC,CE,CH,CS,CY,XE-D,XEE,EC,EE,GG,IN,ME,MN,MT,PE,PH,PI	19			19	GATE Score Only	A, D	AD,AE,AG,AH,AL,AM,AN,AP,AT,AV,BB,BC,BCH,BCT,BE,BM,BN,BP,BPT,BS,BT,CB,CCE,CE,CEE,CF,CH,CJ,CP,CR,CSE,CTE,CU,CY,EC,ECS,ED,EE,EEE,EI,EL,EN,EP,ES,ET,ETE,EV,EX,EY,GG,GS,IB,IC,IE,IM,IN,IP,IR,MAE,MC,MD,ME,MES,MF,MH,MI,MME,MMS,MN,MP,MS,MT,MY,NP,NS,PH,PI,PQ,PR,PS,PW,SA
WM	Water Engineering and Management	AG	10	CE,CH, ES	4	14	GATE Score Only	A	AG,AI,CE,CH,CP,EV,IW,WR