CSIR - Central Mechanical Engineering Research Institute

The Central Mechanical Engineering Research Institute (CMERI) is the apex R&D institute for mechanical engineering. As a constituent member under the Council of Scientific & Industrial Research, the ambit of the Central Mechanical Engineering Research Institute (CMERI) – a premier establishment dedicated to research and development – extends over mechanical and allied engineering fields.

In India, mechanical engineering technology has accounted for nearly half of the total technology imported. In terms of products, nearly one third of the value of total imports is for mechanical engineering equipment. In order to develop indigenously mechanical engineering technology for the industries so that R&D can play a key role in self-reliance, the Central Mechanical Engineering Research Institute at Durgapur, West Bengal was established in February 1958 with the specific task of development of mechanical engineering technology.

Besides conducting frontline research in the varied areas related to mechanical engineering, the Institute dedicates it R&D efforts towards different mission mode programmes to disseminate appropriate technological solutions for poverty alleviation and societal improvement.

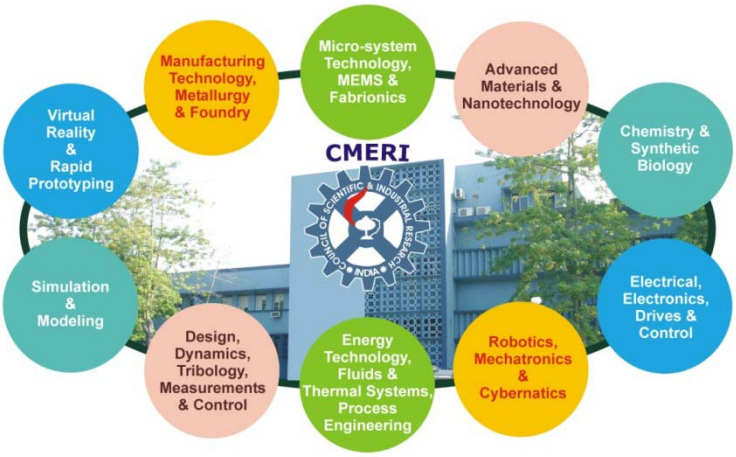
CSIR - CMERI has developed as many as 150 products and processes. More than 120 licensees have obtained know-how for various products and processes developed by CMERI for commercial exploitation. CMERI has filed more than 100 patents, and in recognition to its pioneering role, the Institute has been awarded 26 prestigious national awards for product and process development.

CSIR - CMERI has a dedicated team well balanced in terms of youth and experience of highly qualified professionals and supporting staff spanning the various disciplines under mechanical engineering. The manpower at CMERI's command is comparable to the very best available in this country.

The Institute employs around 400 scientific and technical staff with a rich blend of expertise and experience in different disciplines of engineering sciences.

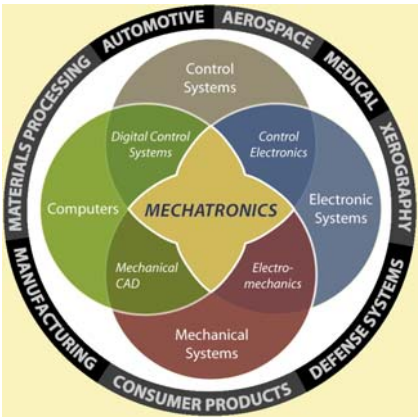
Major Research Areas

The major research areas are represented in the following schematic



Post Graduate Research Programme in Mechatronics

Mechatronics is a design philosophy which encourages engineers to concurrently integrate precision mechanical engineering, digital and analog electronics, control theory and computer engineering in the design of “intelligent” products, systems and processes rather than engineering each set or requirements separately. The advantages of the Mechatronics approach to design are shorter design cycles, lower costs, and elegant solutions to design problems that cannot easily be solved by staying within the bounds of the traditional engineering disciplines. Mechatronics further relates to a multidisciplinary approach to product and manufacturing system design.



The Post Graduate Research Programme in Mechatronics intends to acquaint students with the fundamentals of mechatronics through pedagogy on current theoretical and practical developments in this area. The programme traverses a wide range of applications that comprise robotics, product design, instrumentation, manufacturing methods, computer integration and process & device control, with specific emphasis on innovative engineering. Students undergoing this course are expected to emerge properly equipped to confront challenges across the industrial environment and academic research spectrum.

The Two Year research Programme aims to provide in-depth exposure to the engineering concepts, scientific principles, research methodology and hands-on experience on advanced real-life R&D projects in different specializations related to Mechatronics.

The first semester of the programme focuses on core subjects and associated laboratories related to Mechatronics. The second semester offer elective courses (in addition to core courses) for specialization in different areas falling within the broad domain of Mechatronics. The third and fourth semesters provide opportunity to the candidates to effectively utilize the knowledge acquired through the courses towards advanced R&D project work and dissertation in their specialization areas.

Mode of Payment

The fees/charges need to be deposited at CSIR-CMERI, Durgapur before the start of every semester using the following modes:

- For bank transfer, please transfer the amount to the S/B Acct. 30280331299 of CMERI at SBI, Durgapur (RTGS code SBIN0000074) with appropriate narration statement.
- In case of Demand Draft, please get it issued in favour of “Director, CMERI” payable at Durgapur and post it by speed post or registered letter to “Director, CMERI, Durgapur 713 209” with your name written in pencil on the reverse side of the demand draft.

For other details (Admission Process, Eligibility, Fellowship, Important Dates, fee structure and online application etc.) ***Please visit the CSIR website http://www.csir.res.in/; www.cmeri.res.in***

Detail Description of Programme

SEMESTER I

Sl.	COURSE CODE	COURSE TITLE	HOURS/WEEK			C
			L	T	P	
1.	ENG(CMERI) 1-002	MATHEMATICS FOR ENGINEERS	3	0	0	3
2.	ENG(CMERI) 1-381	INTRODUCTION TO MECHATRONICS SYSTEMS	3	0	0	3
3.	ENG(CMERI) 1-382	ADVANCED CONTROL SYSTEM	3	0	0	3
4.	ENG(CMERI) 1-383	CAD AND COMPUTER GRAPHICS	3	0	1	3
5.	ENG(CMERI) 1-384	ELECTRICAL AND ELECTRONIC CIRCUITS & DEVICES	3	0	0	3
6.	ENG(CMERI) 1-385	MACHINES & MECHANISMS	3	0	0	3
		TOTAL CREDITS				**18**

SEMESTER II

Sl.	COURSE CODE	COURSE TITLE	HOURS/WEEK			C
			L	T	P	
1.	ENG(CMERI) 1-386	ROBOTICS	3	0	1	3
2.	ENG(CMERI) 1-387	MICRO CONTROLLERS & EMBEDDED SYSTEM DESIGN	3	0	1	3
3.	ENG(CMERI) 1-388	DIGITAL SIGNAL PROCESSING & APPLICATIONS	3	0	1	3
4.	ENG(CMERI) 2-----	**Elective I**	3	0	1	3
5.	ENG(CMERI) 2-----	**Elective II**	3	0	1	3
		TOTAL CREDITS				**15**

SEMESTER III

Sl.	COURSE CODE	COURSE TITLE	HOURS/WEEK			C
			L	T	P	
1.	ENG(CMERI) 2-098	MTech DISSERTATION PART-I	0	8	16	16
		TOTAL CREDITS				**16**

SEMESTER IV

Sl.	COURSE CODE	COURSE TITLE	HOURS/WEEK			C
			L	T	P	
1.	ENG(CMERI) 2-099	MTech DISSERTATION PART-II WITH VIVA VOCE	0	8	16	16
		TOTAL CREDITS				**16**

L = Lectures	T = Tutorial	P = Sessional / Lab	C = Credits

ELECTIVES I & II: TWO SUBJECTS TO BE CHOSEN FROM THE FOLLOWING

COURSE CODE	COURSE TITLE	HOURS/WEEK			C
		L	T	P	
ENG(CMERI) 2-381	INTRODUCTION TO COMPUTER VISION	3	0	1	3
ENG(CMERI) 2-382	ROBOTICS & MACHINE INTELLIGENCE	3	0	1	3
ENG(CMERI) 2-383	INTRODUCTION TO NAVIGATION & DATA FUSION	3	0	1	3
ENG(CMERI) 2-384	MICROSYSTEMS TECHNOLOGY	3	0	1	3
ENG(CMERI) 2-385	ADVANCED MATERIALS	3	0	1	3
ENG(CMERI) 2-386	OPTIMAL CONTROL	3	0	1	3
ENG(CMERI) 2-387	PRECISION MACHINE DESIGN	3	0	1	3
ENG(CMERI) 2-388	NUMERICAL METHODS & COMPUTER PROGRAMMING	3	0	1	3
ENG(CMERI) 2-389	ELECTRO-MECHANICAL SYSTEMS DESIGN	3	0	1	3

N.B.

In addition to the dedicated courses listed above for this programme, the candidate may also select any other course as elective on the recommendation of his/her thesis supervisor from the courses enlisted in other Post Graduate program & PhD program in the laboratory.

COURSE DETAILS

ENG(CMERI) 1-002	MATHEMATICS FOR ENGINEERS	L-T-P-C : 3-0-0-3
Course Coordinator: Dr. Pradipta Basu-Mandal		
Linear Algebra: Linear independence, Orthogonality, Vector Spaces and their bases and dimensions, Gram-Schmidt method for orthogonal basis set, Orthogonal projections. Matrices, solution methods for linear simultaneous equations, Eigenvalue problem. Vector Analysis : Vector differentiation, Applications, Vector operators: Grad, Div and Curl. Vector integration & related Integral Theorems, Applications. Cylindrical and Spherical Co-ordinate Systems. Differential Equations: Linear ODEs of first and second orders, Linear second order equations, Applications. The Laplace Transform, Applications. Fourier Series and Applications. Partial differential equations of first and second orders. The Laplace and Wave Equations.		
ENG(CMERI) 1-381	INTRODUCTION TO MECHATRONICS SYSTEM	L-T-P-C : 3-0-0-3
Course Coordinators: Dr. Ranjit Ray & S.N. Shome		
Overview: What is Mechatronics? Instrumentation and Control System. Sensors & Transducers: Physical Principles & Basic mechanisms in sensor systems, performance characteristics, Different type of Sensors and transducers based on principles – Position and Speed Measurement, Stress and Strain Measurement, Temperature Measurement, Vibration and Acceleration Measurement; Actuators: Electromagnetic Principles, Motors – Electric, Hydraulics & Pneumatics; Mathematical Modeling: State space representation, Model Linearization, Sate model from linear graphs, Bond graphs, Modeling Electromechanical Systems. Structures and Materials, Modeling of Mechanical Systems for Mechatronics Applications, Fluid Power, Using MATLAB SIMULINK for modeling and simulation Mechatronics systems; Interfacing & Virtual Instrumentation..		
ENG(CMERI) 1-382	ADVANCED CONTROL SYSTEM	L-T-P-C : 3-0-0-3
Course Coordinators: S. Nandy		
Introduction & Motivation: Role of Controls in Mechatronics, Mathematical Preliminaries, Review of classical control concepts, Root locus technique; Frequency response analysis, Bode Plot, Design of PID Controller, Controller tuning. State Space Design: Modeling of physical systems, Concepts of state, State-space, Representation of Linear system, Controllability and Observability, State Observers. Advance Controller Design: Kalman Filters as Dynamic System State Observers; Linear Quadratic Regulator (LQR) design, Nonlinear Control Design; Describing function, Phase-plane analysis, Fundamentals of Lyapunov Stability Theory (Autonomous Systems), Advanced Stability Theory (Non-autonomous Systems), Feedback Linearization (Input-state & Input-output linearization); Sliding Mode Control.		
ENG(CMERI) 1-383	CAD & COMPUTER GRAPHICS	L-T-P-C : 3-0-1-3
Course Coordinator: Avik Chatterjee		
Genesis of CAD, Simulation and Visualization, Concepts of CAE and Virtual Prototyping; Geometric Object Modeling – Analytical Representation of Curves & Surfaces, Various Curves and Surfaces (B-Spline, Bezier, NURBS), Intersection calculations, Assembly Modeling Techniques; Computer Graphics: Linear algebra, Screen coordinates, Window coordinates, Graphics library, Rendering pipeline architecture, Homogeneous coordinates & Transformation Matrices, Quaternion, Projection matrices, Types of buffers, Display Interpolation techniques, Lightning, Wireframe, Shading models, Texture mapping, Ray casting, Ray tracing, Normal vectors, Evaluators & NURBS, Modeling of sculpture surface, selection and feedback, Concepts of scenes and scene graphics, Hierarchical Modeling Concepts, Kinematic Simulation of an Hierarchical model, Stereo Visualization.		

ENG(CMERI) 1-384	ELECTRICAL AND ELECTRONIC CIRCUITS & DEVICES	L-T-P-C : 3-0-1-3
Course Coordinators: Ms. Uma Datta & J. Roy Choudhury		
Electric Circuits and Components Network Theorems: Thevenin, Norton, Superposition, Maximum Power Transfer. Circuit Analysis, Transformer, Impedance Matching, Grounding and Electrical Interference, Electrical Safety. Semiconductor Electronics: Diodes and its' application; Operation, characteristics : Three terminal devices –- BJT, JFET, MOSFET; Four terminal devices- SCR, Diac, Triac; Amplifiers using BJT, FET; Operational amplifiers Modern devices: CMOS, MESFET, MODFET, HBT. Computing: Number, system and code conversion, Logic gates, Boolean algebra, Combinational / Sequential Logic circuits – Latch, RS-, JK-, T-, D-, Flip flops, Buffer Register, Counters, Shift registers. Decoder, Encoder, MUX, DMUX, RAM, ROM, PROM, EPROM, EEPROM, Programmable logic devices.		
ENG(CMERI) 1-385	MACHINES & MECHANISMS	L-T-P-C : 3-0-0-3
Course Coordinators: P.S. Banerjee & Dr. R. Sen		
Rotation and Plane motion of a rigid body. Kinematic Pairs, Chains, Diagrams. Four Link Planar Mechanisms and their Inversions. Grubler's criterion and Grashof's criterion. Analysis of planar mechanisms – Graphical and Analytical methods Synthesis of planar mechanisms – Motion, Path and Function generation problems - Graphical and Analytical approaches Introduction to Machine Elements – Cams, Gears, Brakes, Clutches etc Cams – classification of cams and followers, nomenclature, description and analysis of follower motion, pressure angle. Determination of basic dimensions, Synthesis of cam profiles – Graphical and Analytical methods. Gears – terminology, fundamental law of gearing, involute profile. Interference and undercutting, Simple, Compound and Epicyclic gear trains.		
ENG(CMERI) 1-386	ROBOTICS	L-T-P-C : 3-0-1-3
Course Coordinators: Dr. Soumen Sen & S.N. Shome		
Robotics introduction; Classification and Components; Rigid body transformation in R3; Homogeneous representation; Denavit-Hertenberg representation; Forward and Inverse kinematics; Redundant and Non-redundant robots; Differential kinematics, velocities, and their transformations; Geometric and analytical Jacobians; Manipulability, Isotropy and Workspace analysis; Manipulator statics; Velocity-force duality; Recursive computation of velocities and accelerations; Manipulator dynamics - Newton-Euler and Euler-Lagrange; Equation of motion; Path planning in joint and task space; Obstacle avoidance and optimal planning; Review of robot control methods; Optimization in robotics; Human-robot interaction; joint and link flexibilities; Walking machines and Exoskeletons; Robot hand and multifingered grasp, manipulation and control; Tendon driven manipulator.		
ENG(CMERI) 1-387	MICROCONTROLLERS & EMBEDDED SYSTEM DESIGN	L-T-P-C : 3-0-1-3
Course Coordinators: J. Roy Chaudhuri & Shikha		
Introduction to embedded systems and architecture, System design using specification and modeling tools Overview of embedded computing platforms; Microprocessors, Microcontrollers, DSP's and SoC's, Hardware – Software design and partitioning Design issues, consideration and trade–offs: Performance memory, power, timing, cost, and development time. Memory hierarchy, System Interfaces and Communication with peripheral units, timers counters, Introduction to Real-time system and Real-time Scheduling Real – time software development: High level languages and Programming issues, Systems performance: Networked		

embedded systems Future Trends, Applications, Tutorial & Laboratory .		
ENG(CMERI) 1-388	DIGITAL SIGNAL PROCESSING & APPLICATIONS	L-T-P-C : 3-0-1-3
Course Coordinators: J. Roy Choudhury & SRK Vadali		
Elements of Analog and Digital Signal Processing, Advantages of Digital over Analog, Sampling Theorem. Discrete Time Signals & Systems – Classification, Analysis of LT Systems, of LTI system Response to Arbitrary Inputs, Causality & Stability; Correlation, Convolution, Finite & Infinite Impulse Response, Recursive & Non-Recursive Systems, Difference Equations. Z-Transform – Definition, Properties; Inverse-Z and Analysis in Z-domain. Fourier Analysis – Continuous & Discrete-Time Fourier Series, Power Density Spectrum, Fourier Transform, Frequency-Domain Characteristics of LTI Systems, DFT & Properties, Linear Filtering Using DFT, Frequency Analysis Using DFT, Understanding FFT. Digital Filter Design – Characteristics & Design of Filters. Future Trends, Applications, Tutorial & Hands-on		

ENG(CMERI) 2-381	INTRODUCTION TO COMPUTER VISION	L-T-P-C : 3-0-1-3
Course Coordinators: Dr. S. Majumdar		
Fundamentals of Computer Vision: Role of vision to achieve simple goals i.e. high level capabilities of vision using cognitive processes, geometric models and low level capability for object perception, representation of images. Computer Vision Research and Application on image formation, camera model and camera calibration, properties of projection, interaction of light and its modeling, perspective modeling, homogeneous coordinate, lens equation, types of image digitizers and image digitizing components. Feature Extraction, filtering and edge detection, fourier transform, texture primitives and texture as a pattern recognition problem, wavelets and multiresolution processing including image pyramids, subband coding, Harr Transform; multiresolution expansions and colour processing. Tutorial on Matlab platform & Project		
ENG(CMERI) 2-382	ROBOTICS AND MACHINE INTELLIGENCE	L-T-P-C : 3-0-1-3
Course Coordinators: J. Roy Choudhury		
Artificial Intelligence, Computational Intelligence, Various Machine Learning Algorithms ,Pattern Reorganization, Computer Vision, Fuzzy Expert System, Fuzzy Automata. Fundamentals Of Robotics & Automation., Intelligent Robots, Control Systems and Components . Robot Motion Analysis and Control,Robot End Effectors,tactile and vision sensors in robotics Cognitive system for Human machine interaction. Future Trends, Applications, Tutorial & Laboratory.		
ENG(CMERI) 2-383	INTRODUCTION TO NAVIGATION & DATA FUSION	L-T-P-C : 3-0-1-3
Course Coordinators: Dr. S. Majumdar		
Sensors, Sensing, Model of Sensors & Process uncertainties Introduction to estimation, estimation methods & relation between different estimators State space modeling, LTI Systems & Kalman Filter & Extended Kalman Filter Other Navigation Filters including Bayesian Filters, Information Filters, Particle Filter etc. Various Sensors used in Robotics: Accelerometer, Gyro, Compass, Encoder, Laser, Ultrasonic Sensor, Camera, Sonar, InfraRed Sensor, Tactile Sensor etc. Multisensor Data Fusion Fundamentals; INS, GPS Aided Navigation & Data Fusion		

Future Trends, Applications, Tutorial & Laboratory		
ENG(CMERI) 2-384	MICRO SYSTEMS TECHNOLOGIES	L-T-P-C : 3-0-1-3
Course Coordinators: Dr. Nagahanumaiah		
Introduction: precision engineering; multi-scale product manufacturing paradigms. Micro- Nano Manufacturing: MEMS foundry processes; micro-mechanical processes; regenerative techniques. Process Modelling: material removal mechanisms; FEA and molecular dynamics based simulations. Design of Micro Machines: sources of error; error mapping; precision drives and controls. Sensors for Precision Manufacturing: sensor systems for process monitoring, multi sensor approaches, signal processing and machine vision systems. Precision Metrology: definitions; laser interferometer; AFM; SEM; TEM. Micro Factory Concepts: micro assembly, composite molding, micro robotics, geometric analysis, decision systems, process planning and micro factory layout designs. Micro-nano systems engineering: module applications; micro-nano scale product design; case studies for biomedical, sensors, and nano technology applications. Tutorial and Laboratory practices.		
ENG(CMERI) 2-385	ADVANCED MATERIALS	L-T-P-C : 3-0-1-3
Course Coordinators: A. Chaudhuri		
Basics: Mechanics of materials, mechanical properties, dislocation theory, mechanical testing methods, creep and relaxation behaviour of common engineering materials Advanced materials: Polymers, conductive polymers, ceramics, composites, nano-composites, smart materials, high temperature materials, bearing materials, materials for sensors and actuators Material characterization: Optical and X-ray spectroscopy, diffraction methods (X-ray diffraction, Crystallographic texture measurements, electron microscopy (SEM, TEM, EBSD, etc.), Atomic probe micro analysis (AFM), Thermo gravity analysis Future Trends, Applications, Tutorial & Laboratory		
ENG(CMERI) 2-386	OPTIMAL CONTROL	L-T-P-C : 3-0-1-3
Course Coordinators: S. Nandy		
Introduction: Problem formulation, Mathematical model, Physical constraints, Form of optimal control, Performance measures, Static optimization techniques. Dynamic Programming and related topics: Introduction, Principle of optimality, Hamilton-Jacobi-Bellman equation, Continuous linear regulator problems, Pontryagin's maximum principle, Control with constraints, Time optimal control, Optimal tracking control problem. Variational Approaches: Calculus of variations, Fundamental concepts, Functionals, Euler's equation, Lagrangian, Variational approach, Optimal control law, Necessary conditions, Linear regulator & tracking problems, Multi-variable optimization problem, Linear Quadratic Regulator. Optimization Methods: Minimum time problems, Minimum control-effort problems, Kalman Filter, Non-linear system optimization, Gradient optimization techniques, Steepest ascent and decent method, Rosenbrock's conjugate gradient method, David-Fletcher-Power method.		
ENG(CMERI) 2-387	PRECISION MACHINE DESIGN	L-T-P-C : 3-0-1-3
Course Coordinators: Dr. N.C. Murmu		
Economics, project management and design philosophy, principles of accuracy, repeatability and resolution; error budgeting. Flexure design - linear and non-linear deflection, stiffness and strength, displacement vs force loads, material considerations, fatigue failure and its prevention. Bearings: rolling contact bearings, flexural bearings, gas bearings and magnetic bearings and design engineering surfaces.		

System design - manufacturing considerations, materials, structural design, joint design, support system and kinematic coupling design, sensors, actuators and transmissions and system integration driven by functional requirements and operating physics. Mini Project – application of theory and heuristics to the design of precision mechanical systems. Tutorial & Mini Project.		
ENG(CMERI) 2-388	NUMERICAL METHODS & COMPUTER PROGRAMMING	L-T-P-C : 3-0-1-3
Course Coordinators: Dr. Partha Bhattacharya		
Introduction, finite floating point arithmetic, catastrophic cancellation, chopping and rounding errors; Solution of nonlinear equations; bisection, , Newton's & Muller's method, fixed point iteration; Numerical optimization, Golden section search, Newton's method optimization; linear algebraic equations; forward Gaussian elimination, pivoting, scaling, back substitution, LU-decomposition, norms and errors, condition numbers, iterations, Newton's method for systems, computer implementation; Interpolation- Lagrange, Newton & inverse ; Numerical Integration; finite differences, Newton cotes, trapezoidal, Simpson's rule, extrapolation, Gaussian quadrature; Numerical solution of ODE; Euler's method, Runge-Kutta method, multi-step methods, predictor-corrector methods, rates of convergence, global errors, algebraic and shooting methods, boundary value problems, computer implementation.		
ENG(CMERI) 2-389	ELECTRO-MECHANICAL SYSTEMS DESIGN	L-T-P-C : 3-0-1-3
Course Coordinators: Dr. Nagahanumaiah		
Introduction: Electro-Mechanical systems and applications: design and analysis of micro-nano positioning systems; ultra precision screw drives; Dual drive positioning systems; flexural joints; design and kinematics analysis of parallel kinematics platforms. High Speed Power Sstems: Distributed loads in electro-mechanical motion drives; Design and dynamic analysis of high speed spindle. Analysis and Synthesis of Fluid Mechanical Systems: hydraulic actuators, micro fluidic flow problems, solving micro pump system design. Instrumentation: sensors, actuators, encoders, servo mechanisms, laser interferometery and other position calibration techniques. Future Trends: Tutorial & Laboratory practices.		
ENG(CMERI) 2-098	MTech DISSERTATION PART-I	L-T-P-C : 0-8-16-16
ENG(CMERI) 2-099	MTech DISSERTATION PART-II WITH VIVA VOCE	L-T-P-C : 0-8-16-16