

B. Tech. in Mechanical Engineering and M. Tech. in Mechatronics

Program Learning Objectives:	Program Learning Outcomes:
- Develop a comprehensive understanding of fundamental principles and advanced concepts in both mechanical engineering and mechatronics disciplines. - Acquire proficiency in applying theoretical knowledge to design, analyze, and optimize mechanical and mechatronic systems and components. - Cultivate practical skills in utilizing modern tools, techniques, and software for modeling, simulation, and prototyping of complex mechanical and mechatronic systems. - Foster interdisciplinary problem-solving abilities to address real-world challenges at the intersection of mechanical engineering and mechatronics. - Encourage innovation and creativity in the design and development of novel mechanical and mechatronic solutions to meet evolving industry and societal needs.	1. Comprehensive Understanding: Students will demonstrate a deep understanding of foundational principles and advanced concepts in mechanical engineering and mechatronics, including mechanics, dynamics, control systems, electronics, and robotics. 2. Application of Knowledge: Students will be able to apply theoretical knowledge to design, analyze, and optimize mechanical and mechatronic systems and components, demonstrating proficiency in problem-solving and critical thinking. 3. Practical Skills: Students will develop practical skills in using modern tools, techniques, and software for modeling, simulation, and prototyping of complex mechanical and mechatronic systems, effectively translating theoretical concepts into tangible solutions. 4. Interdisciplinary Problem-Solving: Students will demonstrate the ability to tackle interdisciplinary challenges by integrating knowledge and techniques from mechanical engineering and mechatronics to develop innovative solutions that address real-world problems. 5. Innovation and Creativity: Students will exhibit creativity and innovation in the design and development of novel mechanical and mechatronic solutions, showcasing originality and adaptability in addressing evolving industry and societal needs.

Sl. No.	Subject Code	SEMESTER VII	L	T	P	C
1.	ME41XX	B.Tech. Elective - I	3	0	0	3
2.	ME41XX	B.Tech. Elective - II	3	0	0	3
3.	XX41PQ	IDE - III	3	0	0	3
4.	HS41PQ	HSS Elective - II	3	0	0	3
5.	ME4198	Summer Internship*	0	0	12	3

6.	MH4199	Mechatronics Project-I	0	0	12	6
7.	MH5101	Fundamentals of Mechatronics	3	0	0	3
8.	EC5105	Embedded System	3	0	2	4
TOTAL			18	0	26	28

***Note :**

For specific cases of internship after VIth Semester, the performance evaluation would be made on joining the VIIth Semester and graded accordingly in the VIIth Semester:

Note :

a) (i) Summer internship (*) period of at least 60 days' (8 weeks) duration begins in the intervening vacation between Semester VI and VII that may be done in industry / R&D / Academic Institutions including IIT Patna. The evaluation would comprise **combined grading based on host supervisor evaluation, project internship report after plagiarism check and seminar presentation at the Department (DAPC to coordinate)** with equal weightage of each of the three components stated herein.

a) (ii) Further, on return from internship, students will be evaluated for internship work through combined grading based on host supervisor evaluation, project internship report after plagiarism check, and presentation evaluation by the parent department with equal weightage of each component.

b) (i) In the VIIth semester, students can opt for a semester long internship on recommendation of the DAPC and approval of the Competent Authority.

b) (ii) On approval of semester long internship, at the maximum two courses (properly mapped/aligned syllabus) at par with institute electives may be opted from NPTEL and / or SWAYAM and the other two more should be done at the institute through course overloading in any other semester (either before or after the internship) and/or during following summer semester.

b) (iii) The candidates opting two courses from NPTEL and / or SWAYAM would be required to appear in the examination at the Institute as scheduled in the Academic Calendar.

Sl. No.	Subject Code	SEMESTER VIII	L	T	P	C
1.	RM6201	Research Methodology	3	1	0	4
2.	MH5201	Sensors and Actuators	3	0	0	3
3.	MH5202	Modeling and Simulation of Mechatronics Systems	3	0	0	3
4.	XX62PQ	M. Tech. Elective – I	3	0	0	3
5.	MH4299	Project-II	0	0	12	6
		TOTAL	12	1	12	19

Sl. No.	Subject Code	SEMESTER IX	L	T	P	C
1.	ME51XX/ ME61XX	M. Tech. Elective - II	3	0	0	3
2.	ME51XX/ ME61XX	M. Tech. Elective - III	3	0	0	3

3.	ME51XX/ EC51XX	M. Tech. Elective - IV	3	0	0	3
4.	MH5199	Mechatronics Project-III**	0	0	16	8
	TOTAL		9	0	16	17

Sl. No.	Subject Code	SEMESTER X	L	T	P	C
1.	MH5299	Mechatronics Project-IV**	0	0	36	18
	TOTAL		0	0	36	18

****Note: M. Tech. Project outside the Institute**

In the IXth Semester, students can opt for a semester long M. Tech. project subject to confirmation from an Institution of repute for research project, on the assigned topic at any external Institution (Industry / R&D lab / Academic Institutions) based on recommendation of the DAPC provided:

(i.) The project topic is well defined in objective, methodology and expected outcome through an abstract and statement of the student pertaining to expertise with the proposed supervisor of the host institution and consent of the faculty member from the concerned department at IIT Patna as joint supervisor.

(ii.) The consent of both the supervisors (external and institutional) on project topic is obtained a priori and forwarded to the academic section through DAPC for approval by the competent authority for office record in the personal file of the candidate.

(iii.) Confidentiality and Non Disclosure Agreement (NDA) between the two organizations with clarity on intellectual property rights (IPR) must be executed prior to initiating the semester long project assignment and committing the same to external organization and vice versa.

(iv.) The evaluation in each semester at Institute would be mandatory and the report from Industry Supervisor will be given due weightage as defined in the Academic Regulation. Further, the final assessment of the project work on completion will be done with equal weightage for assessment of the host and Institute supervisors, project report after **plagiarism check**. The award of grade would comprise **combined assessment based on host supervisor evaluation, project report quality and seminar presentation at the Department (DAPC to coordinate)** with equal weightage of each of the components stated herein.

(v.) In case of poor progress of work and / or no contribution from external supervisor, the student need to revert back to the Institute essentially to fulfill the completion of M. Tech. project as envisaged at the time of project allotment. However, the recommendation of DAPC based on progress report and presentation would be mandatory for a final decision by the competent authority.

GRAND TOTAL (Semester I to X) : 210

ELECTIVE GROUPS

B. Tech. Elective - I						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	ME4101	Tribology and Surface Engineering	3	0	0	3
2.	ME4102	Basics of Computational Fluid Dynamics	3	0	0	3
3.	ME4104	Industrial Automation	3	0	0	3

B. Tech. Elective - II						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	ME4104	Vehicle Dynamics	3	0	0	3
2.	ME4105	Mathematical Modelling of Computer Aided Design	3	0	0	3
3.	ME4106	Energy Engineering	3	0	0	3

M. Tech. Elective - I						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	ME6208	Robot Motion Planning	3	0	0	3
2.	ME6209	Non-linear Systems Dynamics	3	0	0	3
3.	ME6215	Computer Numerical Controlled Machine Tools	3	0	0	3

M. Tech. Elective – II						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	ME6105	Acoustics	3	0	0	3
2.	ME6106	Mobile Robotics	3	0	0	3
3.	ME6107	Digital Manufacturing and Industry 4.0	3	0	0	3

M. Tech. Elective - III						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	ME6103	Continuum Mechanics	3	0	0	3
2.	ME6109	Vehicle Dynamics and Multi-body Systems	3	0	0	3

M. Tech. Elective - IV						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	EC5114	Advanced Digital Image Processing	3	0	0	3
2.	EC6104	VLSI Signal Processing	3	0	0	3

Sl. No.	Subject Code	<u>SEMESTER VII</u>	L	T	P	C
1.	ME41XX	B.Tech. Elective - I	3	0	0	3
2.	ME41XX	B.Tech. Elective - II	3	0	0	3
3.	XX41PQ	IDE - III	3	0	0	3
4.	HS41PQ	HSS Elective - II	3	0	0	3
5.	ME4198	Summer Internship*	0	0	12	3
6.	MH4199	Mechatronics Project-I	0	0	12	6
7.	MH5101	Fundamentals of Mechatronics	3	0	0	3
8.	EC5105	Embedded System	3	0	2	4
TOTAL			18	0	26	28

B. Tech. Elective - I						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	ME4101	Tribology and Surface Engineering	3	0	0	3
2.	ME4102	Basics of Computational Fluid Dynamics	3	0	0	3
3.	ME4104	Industrial Automation	3	0	0	3

Course Number	ME4101
Course Credit	L-T-P-C : 3-0-0-3
Course Title	Tribology and Surface Engineering
Learning Mode	Lectures
Learning Objectives	Complies with PLOs 1 and 4 After attending the class, the students will be able to understand 1. The primary cause of friction and wear in various tribological contact 2. The importance of lubrication and regimes of lubrication in engineering surfaces 3. The use of surface treatment and suitable coatings for the improvement of tribological characteristic 4. The need for different characterization techniques to evaluate the performance of engineering surfaces.
Course Description	This course is designed to understand theories of friction, wear, and lubrication, model basic tribological processes, and understand the influence of surface engineering on tribological contact. Prerequisite: NIL
Course Outline	Introduction – Significance of tribology, history of tribology, Economic Benefits, Interdisciplinary Approach, Need of surface engineering. Surface characteristics – Topography and microstructure of surfaces, Origin of roughness, Measurement of surface characteristics, Roughness parameters, Mechanics of solid surfaces. Friction – Laws of friction, Adhesion theory, Abrasion theory, Stick-slip motion, Rolling friction, Tribological tests. Wear – Adhesive Wear, Abrasive Wear, Delamination Wear, Fretting Wear, Erosive Wear, Corrosive Wear, Oxidative Wear, Wear Mechanism Maps. Lubrication and Lubricants – Boundary Lubrication, Mixed Lubrication, Elasto-Hydrodynamic Lubrication, Hydrodynamic Lubrication, Types and Properties of Lubricants, Lubricants Additives. Applications/ Case study – Sliding contacts, Rolling contacts, Bearing design, Selection of surface treatment/ soft or hard coatings/ surface textures
Learning Outcome	Develop an understanding of the characteristics of tribological contact of moving engineering components and ways to prevent failure or increase the life of such components.
Assessment Method	Assignments, Quiz, Mid-semester and End-semester exams
Suggested Readings: Text Books: [1] R.D. Arnell, P.B. Davies, J. Halling, T.L. Whomes, Tribology: principles and design applications, Macmillan Education Ltd, First edition 1991. [2] B. Bhushan, Principles and Applications of Tribology, John Wiley, second edition, 2013. [3] A. Cameron, Basic Lubrication Theory, E. Horwood, Halsted Press, 1976. [4] I. Hutchings, P. Shipway, Tribology: friction and wear of engineering materials, Butterworth-heinemann, 2nd Edition, 2017. [5] G. Stachowiak, A.W. Batchelor, Engineering tribology, Butterworth-heinemann, Fourth edition, 2013. [6] B. J. Hamrock, B. O. Jacobson, S. R. Schmid, Fundamentals of Machine Elements, McGraw-Hill Inc., 1998.	

[7] K. S. Edwards, R. B. McKee, Fundamentals of Mechanical Component Design, McGraw-Hill Inc., 1991.

Course Name	Basics of Computational Fluid Dynamics
Course Number	ME4102
L-T-P-C	3-0-0-3
Pre-requisites	Undergraduate Fluid Mechanics and Heat Transfer course
Learning Mode	Class room lecture
Course objectives	
Complies with PLOs 2 and 4 This course is designed to fulfil the basic concepts of computational fluid dynamics. The course first discusses the general background required for understanding the various numerical methods or discretization techniques involved in CFD. It is followed by a detailed understanding of the two of the popular discretization methods – Finite Difference Method (FDM) and Finite Volume Method (FVM).	
Course Content	
Concept of Computational Fluid Dynamics: Different techniques of solving fluid dynamics problems, their merits and demerits, governing equations of fluid dynamics and boundary conditions, classification of partial differential equations and their physical behavior, Navier-Stokes equations for Newtonian fluid flow, computational fluid dynamics (CFD) techniques, different steps in CFD techniques, criteria and essentialities of good CFD techniques. Finite Difference Method (FDM): Application of FDM to model problems, steady and unsteady problems, implicit and explicit approaches, errors and stability analysis, direct and iterative solvers. Finite Volume Method (FVM): FVM for diffusion, convection-diffusion problem, different discretization schemes, FVM for unsteady problems. SIMPLE family FVM for solving Navier-Stokes equation	
Learning Outcomes: After attending this course, the following outcomes are expected: 1. Ability to classify the partial differential equations involved in fluid mechanics and heat flow and understanding of their physical behaviour. 2. Ability to write CFD codes for the various algorithms covered in this course.	
Assessment Method Quiz, mid and end semester examinations, Coding Assignments, Viva	
Texts and References	
Text Books: 1. J. D. Anderson, “Computational Fluid Dynamics”, McGraw-Hill Inc. (New Edition). 2. S. V. Patankar, “Numerical Heat Transfer and Fluid Flow”, Hemisphere Pub. (New Edition) 3. D. A. Anderson, J. C. Tannehill and R. H. Pletcher, “Computational Fluid Mechanics And Heat Transfer”, Hemisphere Pub. (New Edition) 4. M. Peric and J. H. Ferziger, “Computational Methods for Fluid Dynamics”, Springer (New Edition). 5. H. K. Versteeg and W. Malalaskera, “An Introduction to Computational Fluid Dynamics”, Dorling Kindersley (India) Pvt. Ltd. (New Edition).	

Reference Books:

1. C. Hirsch, “Numerical Computation of Internal and External Flows”, ButterworthHeinemann, (New Edition).
2. K. Muralidhar, and T. Sundarajan, “Computational Fluid Flow and Heat Transfer”, Narosa (New Edition)
3. A. Sharma, “Introduction to Computational Fluid Dynamics Development, Application and Analysis”, Ane Books, 1st edition 2016

Course Name	Industrial Automation
Course Number	ME4104
L-T-P-C	3-0-0-3
Pre-requisites	Nil
Learning Mode	Class room lecturer
Course objectives	
Complies with PLOs 3 and 4 • To gain fundamental principles of industrial automation approaches. • To understand the various pneumatic, hydraulic actuators, valves, sensors. • To gain concept of pneumatic, hydraulic and electro-pneumatic/-hydraulic circuit design for different activities/operations. • To gain concepts of automatic transfer lines, assembly systems.	
Course Content	
Fundamental concepts and types of automation, Various automation strategies. Introduction to Pneumatics and Hydraulics, Electro-pneumatic, and Electro-hydraulic devices: Basic elements of Pneumatics/Hydraulics and Electro-pneumatic/-hydraulic systems, construction and working of pneumatic/hydraulic cylinders and actuators, their mounting and operations, Pneumatic and hydraulic valves for flow, pressure control, direction control valves, Solenoid valves, Gates, Feedback systems; Pneumatic and hydraulic element symbols. Circuit design of pneumatic/hydraulic, electro-pneumatic systems for various sequence of operations. Control circuits for various applications like clamping, releasing, counting, stopping, safety and similar operations. Flexible manufacturing systems: Automatic transfer, feeding, orientation devices. Various automatic transfer machines, Automated transfer lines with and without buffer storage, Automatic storage and retrieval systems, Group technology.	
Learning Outcomes: By the end of this course, undergraduate students should be able to: • explain the working of various pneumatic and hydraulic components, • select the suitable devices for designing pneumatic and hydraulic systems required for automated operations, • design the pneumatic/hydraulic circuits and understand the working of such system, • understand the automation in manufacturing and assembly operations.	
Assessment Method • Quiz, Assignments, Mid and End semester examinations	
Texts and References	
Text Books: [1] Groover, M. P., Automation, Production System & Computer Integrated Manufacturing, Pearson Education Asia (2004). [2] Majumdar, S. R., Pneumatic Systems, McGraw Hill (2005). Reference Books: [1] Nakra, B. C., Automatic Control, New Age International (2005). [2] Morriss, S. B., Automataed Manufacturing Systems, McGraw Hill (2006).	

B. Tech. Elective - II						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	ME4104	Vehicle Dynamics	3	0	0	3
2.	ME4105	Mathematical Modelling of Computer Aided Design	3	0	0	3
3.	ME4106	Energy Engineering	3	0	0	3

Course Name	Vehicle Dynamics
Course Number	ME4104
L-T-P-C	3-0-0-3
Pre-requisites	Engineering Mechanics/Dynamics or equivalent course
Learning Mode	Class room lecture
Course objectives	
Complies with PLOs 1 and 4 By the end of this course, undergraduate students should be able to: • Understand rigid body dynamics analysis of wheeled vehicle system. • Develop models for handling and stability of vehicle.	
Course Content	
1. Introduction to vehicle dynamics: Vehicle coordinate systems; loads on axles of a parked car and an accelerating car. Acceleration performance: Power-limited acceleration, traction-limited acceleration. 2. Tire models: Tire construction and terminology and mechanics of force generation; 3. Aerodynamic effects on a vehicle: Mechanics of airflow around the vehicle 4. Braking performance: Equations for braking for a vehicle with constant deceleration and deceleration with wind-resistance 5. Steering systems and cornering: Geometry of steering linkage, steering geometry error; steering system models 6. Suspension and ride: Suspension types—solid axle suspensions, independent suspensions; suspension geometry; roll center analysis; active suspension systems; 7. Vehicle rider excitation and comfort; 8. Roll-over: Quasi-static roll-over of rigid vehicle and suspended vehicle; transient roll-over, yaw-roll model, tripping, use of standards for design.	
Learning Outcomes: • Mathematical modeling of the vehicle dynamic system with integrations of various subsystems • Understanding of the stability, rider comfort and rollover limits of the vehicle. • Use of simulation tools for developing the analytical model	
Assessment Method • Quiz, mid and end semester examinations	
Texts and References	
Text Books: 1. T.D. Gillespie, “Fundamental of Vehicle Dynamics”, SAE Press (1995). 2. J.Y. Wong, “Theory of Ground Vehicles”, 4th Edition, John Wiley & Sons (2008). 3. Reza N. Jazar, “Vehicle Dynamics: Theory and Application”, 1st Edition, Springer (2008). 4. R. Rajamani, “Vehicle Dynamics and Control”, Springer (2006). 5. H. Baruh, Analytical Dynamics, McGraw-Hill, 1999. Reference Books: 1. G. Genta, “Motor Vehicle Dynamics”, World Scientific Pub. Co. Inc. (1997). 2. H.B. Pacejka, “Tyre and Vehicle Dynamics”, SAE International and Elsevier (2005). 3. Dean Karnopp, “Vehicle Stability”, Marcel Dekker (2004). 4. U. Kiencke and L. Nielsen, “Automotive Control System”, Springer-Verlag, Berlin. 5. M. Abe and W. Manning, “Vehicle Handling Dynamics: Theory and Application”, 1st Edition, Elsevier (2009).	

Course Number	ME4105
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Mathematical Modelling of Computer Aided Design
Learning Mode	Classroom mode
Learning Objectives	Complies with PLOs 1, 3 and 4 By the end of this course, students will be able to: 1. Understand the mathematical concepts underlying CAD. 2. Apply mathematical techniques to model geometric entities. 3. Develop algorithms for geometric modelling. 4. Analyze and solve geometric problems using numerical methods.
Course Description	Implement mathematical models in CAD software. This course explores the mathematical foundations and algorithms used in computer-aided design (CAD). Students will learn about various mathematical techniques and their applications in creating, analyzing, and manipulating geometric models. The course covers topics such as curves, surfaces, solid modelling, transformations, and numerical methods. Prerequisite: NIL
Course Outline	Introduction to Mathematical Modelling in CAD: Overview of CAD and its applications, Importance of mathematical modelling in CAD, Introduction to geometric modelling Coordinate Systems and Transformations: Cartesian and polar coordinate systems, Homogeneous coordinates, Affine transformations (translation, scaling, rotation), Composite transformations Curves in CAD: Parametric representation of curves, Polynomial curves, Bezier curves, B-splines and NURBS Surface Modelling: Parametric representation of surfaces, Bezier surfaces, B-spline surfaces, Surface-surface intersections Solid Modelling: Solid representation schemes (CSG, B-rep), Boolean operations on solids, Boundary representation (B-rep), Euler operators Geometric Interrogation: Curve and surface fitting, Intersection algorithms, Distance and angle calculations, Surface evaluation Numerical Methods in CAD: Numerical integration and differentiation, Root-finding algorithms (Newton-Raphson method), Numerical solutions of linear systems, Optimization techniques Advanced Topics in Curve and Surface Modelling: Subdivision surfaces, Implicit surfaces, Mesh generation and processing, Curve and surface smoothing Computer Graphics in CAD: Basics of computer graphics, Rasterization and rendering, Shading and lighting models, Visualization of geometric models
Learning Outcome	This course would enable the students to understand the mathematical concepts underlying CAD to apply mathematical techniques to model geometric entities and to develop algorithms for geometric modelling
Assessment Method	Mid Semester Examination, End Semester examination, Class test & quiz, Assignment, Mini Project
Text Books: [1] "Mathematical Elements for Computer Graphics" by David F. Rogers and J. Alan Adams [2] "Curves and Surfaces for Computer-Aided Geometric Design" by Gerald Farin [3] "Geometric Modeling" by Michael E. Mortenson [4] "Numerical Methods for Engineers" by Steven C. Chapra and Raymond P. Canale	

Course Number	ME4106
Course Credit	L-T-P-C: 3-0-0-3
Course Title	Energy Engineering
Pre-requisite	Thermodynamics
Learning Mode	Lectures
Learning Objectives	Complies with PLOs 2 and 4 The objective of this course is, • To impart the knowledge of various sources of conventional and nonconventional energy. • To impart the knowledge of working principle of different types of power plants and their conversion efficiency. • To develop skill in renewable and non-renewable energy technology. • To design and analyze energy systems, considering sustainability and economic factors.
Course Description	This course is designed to provide the concepts of various energy sources, energy conversion principles, power plants.
Course Outline	Conventional Energy Sources: Hydel, Steam, Gas turbine, Diesel and Nuclear Power Plant, Layout, function of different components and types, Energy and Exergy analyses of power plants. Power plant Economics. Non-conventional or Renewable energy sources: Solar energy, application of solar energy, Wind, Ocean, Geothermal, Biomass Energies, Energy Conversion Principles and types. Energy and Exergy analyses of non-conventional/renewable energy conversion units. Carbon footprint.
Learning Outcome	Following learning outcomes are expected after going through this course. • Will be able to understand various sources of conventional and nonconventional energy. • Will be able to select appropriate and efficient power plant based on the availability of energy sources. • Will be able to design and analyse various energy conversion systems considering sustainability and economic factors.
Assessment Method	Mid Semester Examination (25%), End Semester examination (35%), Class test & quiz (30%), Assignment (10%)
Suggested Readings: 1. PK Nag, Power Plant Engineering, Tata McGraw Hill, 5th Ed. 2012. 2. M.M.El. Wakil, Power Plant Techniques, McGraw Hill, New York, 1985. 3. Sukathme S.P., Solar Energy Principles of Thermal Collection and Storage, 2nd Ed., TMC New Delhi, 1984. 4. John R. Lamarsh and Anthony J. Baratta, "Introduction to Nuclear Engineering", Prentice Hall, 2001. 5. Elmer E. Lewis, "Fundamentals of Nuclear Reactor Physics", Academic Press Inc., 2008. 6. Houghton E.L., Carruthers, Aerodynamics for Engineering students, Butterworth-Hinemann Ltd., 2006.	

Course Number	MH4199
Course Credit	0-0-12-6
Course Title	Mechatronics Project - I
Course Learning Objective: Complies with PLOs 1-5 • This course provides students with an opportunity to apply their theoretical knowledge and practical skills in Mechatronics to a real-world engineering project. • Working in teams of maximum two, students will conceptualize, design, implement, and demonstrate a mechatronic system or device. • Emphasis will be placed on interdisciplinary collaboration, project management, problem-solving, and communication skills. Course Learning Outcome: • Apply principles of Mechatronics to identify and define a project problem or opportunity. • Design and develop a mechatronic system or device to meet specified requirements. • Implement and integrate mechanical, electrical, and software components to build the project prototype. • Test, troubleshoot, and refine the project prototype through iterative design iterations. • Demonstrate the functionality and performance of the project prototype through a formal presentation and documentation. • Work effectively in a team environment, demonstrating communication, collaboration, and leadership skills. • Reflect on the project experience and identify lessons learned for future engineering endeavors. Contents: Introduction to Mini-Project Course and Project Selection; Overview of course objectives, expectations, and deliverables; Project proposal submission and approval process; Team formation and roles assignment; Project Planning and Management; Project scope definition and requirements analysis; Project planning, scheduling, and resource allocation; Risk assessment and mitigation strategies; Conceptual Design and System Specification; Brainstorming and idea generation techniques; System architecture design and component selection; Functional decomposition and system specification development; Detailed Design and Component Integration; Detailed mechanical design and CAD modeling; Electrical circuit design and component layout; Software development and programming for control and interface; Prototype Fabrication and Assembly; Fabrication of mechanical components using machining, 3D printing, etc.; Assembly of electrical and electronic components; Integration of software modules and system calibration Testing, Validation, and Iterative Improvement; Functional testing and validation of individual subsystems; Integration testing and system verification; Iterative design refinement based on test results and feedback; Project Documentation and Presentation; Preparation of project documentation, including design reports, technical drawings, and user manuals; Development of a formal project presentation; Final project demonstration and evaluation	

Course Number	MH5101
Course Credit	L-T-P-Cr: 3-0-0-3
Course Title	Fundamentals of Mechatronics
Learning Mode	Lectures
Learning Objectives	Complies with PLOs 1-5 This course concerns the synergistic application of mechanics, electronics, controls, and computer engineering in the development of electromechanical products and systems through an integrated design approach. A mechatronic system will require a multidisciplinary approach for its modelling, design, development, and implementation. In the traditional development of an electromechanical system, the mechanical components and electrical components are designed or selected separately and then integrated, possibly with other components and hardware and software. In contrast, in the mechatronic approach, the entire electromechanical system is treated concurrently in an integrated manner by a multidisciplinary team of engineers and other professionals. Naturally, a system formed by interconnecting a set of independently designed and manufactured components will have a lower level of performance than that of a mechatronic system, which employs an integrated approach for design, development, and implementation. Through this course fundamentals behind the mechatronics approach shall be detailed and discussed.
Course Description	This course is designed to fulfil the introductory assessment of different electronics devices as well as different mechanical drives related to Mechatronics applications. Prerequisite: NIL
Course Outline	Module I: Introduction: Definition of Mechatronics, Mechatronics in manufacturing, Products, and design. Comparison between Traditional and Mechatronics approach Module II: Review of fundamentals of electronics. Data conversion devices, sensors, microprocessors, transducers, signal processing devices, relays, contactors and timers. Microprocessors, Microcontrollers and PLCs. Module III: Review of fundamentals of mechanical components: Drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, transfer systems Module IV: Modelling of simple mechanical and electric systems; Building up transfer functions of dynamic systems; Block diagram analysis; Introduction to open and closed loop systems; Dynamic responses of first order and second order systems; Input signals, system stability and dynamic errors; PID Controller design and system improvement.
Learning Outcome	After attending this course, the following outcome can be expected ➤ Comparison between Traditional and Mechatronics approach shall be found.

	➤ Different electronics devices e.g., data conversion devices, sensors, microprocessors, transducers, signal processing devices, relays, contactors and timers. Microprocessors controllers and PLCs shall be detailed. ➤ Different mechanical drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, transfer systems shall be discussed. ➤ PID controllers. CNC machines and part programming. Industrial Robotics shall be introduced.
Assessment Method	Mid Semester Examination (20%), End Semester Examination (40%), Class Test (10%) & Quiz (10%), Assignment (20%).
Suggested Readings: Text Books: 1. HMT Ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988. 2. G.W. Kurtz, J.K. Schueller, P.W. Claar II, Machine design for mobile and industrial applications, SAE, 1994. 3. T.O. Boucher, Computer automation in manufacturing - an Introduction, Chappman and Hall, 1996. 4. R. Iserman, Mechatronic Systems: Fundamentals, Springer, 1st Edition, 2005 5. Musa Jouaneh, Fundamentals of Mechatronics, 1st Edition, Cengage Learning, 2012 6. Clarence W. de Silva, MECHATRONICS A Foundation Course, CRC Press, Taylor & Francis Group, 2010.	

Course Number	EC5105
Course Credit	L-T-P-C: 3-0-2-4
Course Title	Embedded System
Learning Mode	Lectures and Labs
Learning Objectives	Complies with Program Goals 1, 2, 3 and 4
Course Description	Embedded Systems focus on the design and integration of hardware and software in specialized computing systems. The course explores real-time operating systems, microcontrollers, and applications in various domains.
Course Outline	Introduction to the Embedded systems, Basics of Microprocessors and Microcontrollers, Embedded System models and Development Cycle, Embedded system design constraints Sensors, Actuators, Embedded processor and memory architecture, Analog to Digital (A/D) convertors, D/A convertors Introduction to different processors, Arduino-Architecture, communication, Field Programmable Gate Array (FPGA)-configurable logic blocks, ARM Processor- Architecture, Instruction Set, Pipelining, Interfacing, Pulse Width Modulation Communication Interfaces: Serial and Parallel communication, Onboard Communication Interfaces (UART, SPI, I2C) and External Communication Interfaces (IR, Wireless-Bluetooth, Wireless LAN, USB, Ethernet etc.), Introduction to Embedded OS and RTOS, Task scheduling-clock-driven and event-driven, RMA and EDF scheduling, Voltage Scheduling, priority inversion, inheritance and ceiling protocol, Multi-tasking State Charts, Finite State Machines, Hierarchical state machines, Program State Machines, Specification and description language (SDL), Embedded system analysis and verification.
Learning Outcomes	Complies with PLOs 1a, 1b, 2 and 3a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<u>Text/References</u> 1. P. Marwedel: Embedded System Design, Springer, ISBN978-3-319-56045-8,2018. 2. G.C.Buttazzo:HardReal-TimeComputingSystems.SpringerVerlag,ISBN978-1-4614-0676-1,2011. 3. Peter Marwedel, “Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems”, Springer, 2011. 4. Edward A.Lee and Sanjit A .Seshia: Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, MIT Press, ISBN978-0-262-53381-2,2017. 5. M.Wolf: Computers as Components–Principles of Embedded System Design. Morgan Kaufman Publishers , ISBN978-0-128-05387-4,2016. 6. Mazidi & Mazidi, “8051MicrocontrollerandEmbeddedSystems” Steve Furber,—ARM System-On-Chip Architecture, Second Edition, Pearson Publisher,2015.

	7. Shibu K V, —Introduction to Embedded Systems, Tata McGraw Hill Education Private Limited, 2009. 8. Steve Furber, — ARM System-On-Chip Architecture, Second Edition, Pearson Publisher, 2015. 9. N. Sloss, D. Symes, and C. Wright, "ARM system developer's guide: Designing and optimizing and system software", Elsevier, 2008.
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Sl. No.	Subject Code	<u>SEMESTER VIII</u>	L	T	P	C
1.	RM6201	Research Methodology	3	1	0	4
2.	MH5201	Sensors and Actuators	3	0	0	3
3.	MH5202	Modeling and Simulation of Mechatronics Systems	3	0	0	3
4.	XX62PQ	M. Tech. Elective – I	3	0	0	3
5.	MH4299	Project-II	0	0	12	6
		TOTAL	12	1	12	19

Course Number	RM6201
Course Credit (L-T-P-C)	3-1-0-4
Course Title	Research Methodology
Learning Mode	Lectures
Learning Objectives	The objective of the course is to train student about the modelling of scalar and multi-objective nonlinear programming problems and various classical and numerical optimization techniques and algorithms to solve these problems
Course Description	Advanced Optimization Techniques, as a subject for postgraduate and PhD students, provides the knowledge of various models of nonlinear optimization problems and different algorithms to solve such problems with its applications in various problems arising in economics, science and engineering.
Course Content	Module I (6 lecture hours) – Research method fundamentals: Definition, characteristics and types, basic research terminology, an overview of research method concepts, research methods vs. method methodology, role of information and communication technology (ICT) in research, Nature and scope of research, information based decision making and source of knowledge. The research process; basic approaches and terminologies used in research. Defining research problem and hypotheses framing to prepare a research plan. Module II (5 lecture hours) - Research problem visualization and conceptualization: Significance of literature survey in identification of a research problem from reliable sources and critical review, identifying technical gaps and contemporary challenges from literature review and research databases, development of working hypothesis, defining and formulating the research problems, problem selection, necessity of defining the problem and conceiving the solution approach and methods. Module III (5 lecture hours) - Research design and data analysis: Research design – basic principles, need of research design and data classification – primary and secondary, features of good design, important concepts relating to research design, observation and facts, validation methods, observation and collection of data, methods of data collection, sampling methods, data processing and analysis, hypothesis testing, generalization, analysis, reliability, interpretation and presentation. Module IV (16 lecture hours) - Qualitative and quantitative analysis: Qualitative Research Plan and designs, Meaning and types of Sampling, Tools of qualitative data Collection; observation depth Interview, focus group discussion, Data editing, processing & categorization, qualitative data analysis, Fundamentals of statistical methods, parametric and nonparametric techniques, test of significance, variables, conjecture, hypothesis, measurement, types of data and scales, sample and sampling techniques, probability and distributions, hypothesis testing, level of significance and confidence interval, t-test, ANOVA, correlation, regression analysis, error analysis, research data analysis and evaluation using software tools (e.g.: MS Excel, SPSS, Statistical, R, etc.).

	Module V (10 lecture hours) – Principled research: Ethics in research and Ethical dilemma, affiliation and conflict of interest; Publishing and sharing research, Plagiarism and its fallout (case studies), Internet research ethics, data protection and intellectual property rights (IPR) – patent survey, patentability, patent laws and IPR filing process.
Learning Outcome	On successful completion of the course, students should be able to: 1. Understand the terminology and basic concepts of various kinds of nonlinear optimization problems. 2. Develop the understanding about different solution methods to solve nonlinear Programming problems. 3. Apply and differentiate the need and importance of various algorithms to solve scalar and multi-objective optimization problems. 4. Employ programming languages like MATLAB/Python to solve nonlinear programming problems. 5. Model and solve several problems arising in science and engineering as a nonlinear optimization problem.
Assessment Method	Quiz /Assignment/ Project / MSE / ESE

Textbooks & Reference Books:

1. C. R. Kothari, Research methodology: Methods and Techniques, 3rd Edn., New age International 2014.
2. Mark N K. Saunders, Adrian Thornhill, Phkip Lewis, “Research Methods for Studies, 3/c Pearson Education, 2010.
3. K.N. Krishnaswamy, apa iyer, siva kumar, m. Mathirajan, “Management Research Methodology”, Pearson Education, 2010.
4. Ranjit Kumar; “Research Methodology: A Step by Step Guide for Beginners; 2/e; Pearson Education, 2010.
5. Suresh C. Sinha, Anil K. Dhiman, ess ess, 2006 “Research Methodology” Panner Selvam.R. “Research Methodology”, Prentice Hall of India, New Delhi, 2004.
6. C.G. Thomas, Research methodology and scientific writing, Ane books, Delhi, 2015.
7. H. J. Ader and G. J. Mellenbergh, Research Methodology in the Social, Behavioural and Life Sciences Designs, Models and Methods, 3rd Edn., Sage Publications, London, 2000.

Course Number	MH5201
Course Credit	L-T-P-Cr: (3-0-0-3)
Course Title	Sensors and Actuators
Learning Mode	Lectures
Learning Objectives	Complies with PLOs 1 - 5 Understanding the working and design of sensors and actuators. To provide knowledge on integrating different order and multiphysics dynamic systems for accurate measurement and actuation
Course Description	Understanding of the working and design of measurement systems- classification, characteristics and calibration of different sensors. Modelling and analysis of electromechanical, Hydraulic, pneumatic, Piezoelectric and SMA actuators
Course Outline	Brief overview of measurement systems, classification, characteristics and calibration of different sensors. Measurement of displacement, position, motion, force, torque, strain gauge, pressure flow, temperature sensor sensors, smart sensor. Optical encoder, tactile and proximity, ultrasonic transducers, opto-electrical sensor, gyroscope. Principles and structures of modern micro sensors, micro-fabrication technologies: bulk micromachining, surface micromachining, LIGA, assembly and packaging Pneumatic and hydraulic systems: actuators, definition, example, types, selection. Pneumatic actuator. Electro-pneumatic actuator. Hydraulic actuator, control valves, valve sizing valve selection. Electrical actuating systems: solid-state switches, solenoids, voice coil; electric motors; DC motors, AC motors, single phase motor; 3-phase motor; induction motor; synchronous motor; stepper motors. Piezoelectric actuator: characterization, operation, and fabrication; shape memory alloys
Learning Outcome	Understanding the dynamics of sensors and actuators so as to integrate with system for measurement /actuation. Learning Systems Dynamics and being able to predict the rang of operations of multi-physics sensors and actuators
Assessment Method	Assignments, Quiz, Viva and Examination –Midterm and End term
	Suggested Readings: 1. John G. Webster, Editor-in-chief, “Measurement, Instrumentation, and Sensors Handbook”, CRC Press (1999). 2. Jacob Fraden, “Handbook of modern Sensors”, AIP Press, Woodbury (1997). 3. Nadim Maluf, “An Introduction to Microelectromechanical Systems Engineering”, Artech House Publishers, Boston (2000). 4. Marc Madou, “Fundamentals of Microfabrication”, CRC Press, Boca Raton (1997). 5. Gregory Kovacs, “Micromachined Transducers Sourcebook”, McGraw-Hill, New York (1998). 6. E. O. Deobelin and D. Manik, “Measurement Systems – Application and Design”, Tata McGraw-Hill (2004).

	7. D. Patranabis, "Principles of Industrial Instrumentation", Tata McGraw-Hill, eleventh reprint (2004). 8. B. G. Liptak, "Instrument Engineers' Handbook: Process Measurement and Analysis", CRC (2003)
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Course Number	MH5202
Course Credit	L-T-P-Cr: 3-0-0-3
Course Title	Modelling and Simulation of Mechatronic Systems
Learning Mode	Lectures
Learning Objectives	Complies with PLOs 1-5 The objective of this course is • To impart the ability of analysing different mechatronics system in a unified way. • To impart the ability of deriving the governing equation of motion in electromechanical system • To impart the ability of solving obtained governing equation numerically • To impart the ability of analysing obtained simulation results for designing different mechatronics systems • To impart the ability designing different mechatronics system through frequency domain analysis
Course Description	This course is designed to fulfil the requirement of unified modelling approach in mechatronics system where systems are of multi energy domain. Besides the simulation technique will also be addressed in this course. Prerequisite: NIL
Course Outline	Physical Modelling: Mechanical and electrical systems, physical laws, continuity equations, compatibility equations, system engineering concept, system modelling with structured analysis, modelling paradigms for mechatronic system, block diagrams, mathematical models, systems of differential-algebraic equations, response analysis of electrical systems, thermal systems, fluid systems, mechanical rotational system, electrical-mechanical coupling. Simulation Techniques: Solution of model equations and their interpretation, zeroth, first and second order system, solution of 2nd order electro-mechanical equation by finite element method, transfer function and frequency response, non-parametric methods, transient, correlation, frequency, Fourier and spectra analysis, design of identification experiments, choice of model structure, scaling, numeric methods, validation, methods of lumped element simulation, modelling of sensors and actuators, hardware in the loop simulation (HIL), rapid controller prototyping, coupling of simulation tools, simulation of systems in software (MATLAB, LabVIEW) environment. Modelling and Simulation of Practical Problems: • Pure mechanical models • Models for electromagnetic actuators including the electrical drivers • Models for DC-engines with different closed loop controllers using operational amplifiers • Models for transistor amplifiers Models for vehicle system

Learning Outcome	Following learning outcomes are expected after going through this course. - Will be able to derive system equation of mechatronics system through Lagrange's equation, Hamilton's equation, Hamilton's principle and Bond Graph approaches. - Will be able to apply the notion of Galilean Causality - Will be able obtain the state space equations for several mechatronics systems like Electrical machines including transformer, multibody dynamics including vehicle dynamics and Euler's angle, hydraulics, sensors and actuators, - Will be able to solve state space equations numerically through Runge-Kutta Method in Matlab or in Python languages. - Will be able to derive and analyse deformable body dynamics including modes, nodes in different coordinate systems like generalized coordinates, modal coordinates and normalized coordinates. - Will be able to derive the linear system's response for any arbitrary excitation - Will be able to design different mechatronics systems like seismic instruments through frequency domain analysis
Assessment Method	Mid Semester Examination, End Semester examination, Class test & quiz, Assignment, Weightage of different components of assessment will be as per the Senate.
Suggested Readings: Text Books: L. Ljung, T. Glad, "Modeling of Dynamical Systems", Prentice Hall Inc. (1994). - D.C. Karnopp, D.L. Margolis and R.C. Rosenberg, "System Dynamics: A Unified Approach", 2nd Edition, Wiley-Interscience (1990). G. Gordon, "System Simulation", 2nd Edition, PHI Learning (2009). V. Giurgiutiu and S. E. Lyshevski, "Micromechatronics, Modeling, Analysis, and Design with MATLAB", 2nd Edition, CRC Press (2009).	

M. Tech. Elective - I						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	ME6208	Robot Motion Planning	3	0	0	3
2.	ME6209	Non-linear Systems Dynamics	3	0	0	3
3.	ME6215	Computer Numerical Controlled Machine Tools	3	0	0	3

Course Number	ME6208
Course Credit	L-T-P-Cr : 3-0-0-3
Course Title	Robot Motion Planning
Pre-requisite	Mobile Robotics
Learning Mode	Classroom Lecture
Learning Objectives	Complies with PLOs 1, 2 and 4 • This course covers the prominent motion planning algorithms used in the area of mobile robotics. • The course will cover various motion planning algorithms and analyses.
Course Description	This course introduces students to motion planning algorithm theory and implementation which is a crucial enabling technology for imparting higher degree of autonomy to robots. Prerequisite: ME51XX/ME52XX Mobile Robotics
Course Outline	Configuration space and topology: Homeomorphism and diffeomorphism, differential manifolds, connectedness and compactness, parameterization of $SO(3)$ Potential functions: Additive attractive/repulsive potential, distance computation using Brushfire algorithm, local minima problem, wave-front planner, navigation potential functions, sphere-space and star-space, potential function in non-Euclidean spaces Roadmaps: Visibility maps, Generalized Voronoi Diagram, Retract-like Structures, Canny's Roadmap algorithm, opportunistic path planner Cell decomposition: Trapezoidal decomposition, Morse cell decompositions, Visibility-based decompositions for Pursuit/Evasion; Sampling-based algorithms: Probabilistic roadmaps, Expansive spaces trees, Rapidly-Exploring Random Trees, Analysis of PRM.
Learning Outcome	After completing this course, the students will be able to implement and analyse robot motion planning algorithms.
Assessment Method	Mid Semester Examination, End Semester examination, Class test and quiz, Programming Assignments
Suggested Readings: Text Book: [1] H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki and S. Thrun, Principles of Robot Motion: Theory, Algorithms, and Implementations, MIT Press, Boston, 2005. Reference Book: [1] S. M. LaValle, "Planning Algorithms", Cambridge University Press, 2006. (Available online http://planning.cs.uiuc.edu/)	

Course Number	ME6209
Course Credit	L-T-P-Cr : 3-0-0-3
Course Title	Nonlinear Systems Dynamics
Learning Mode	Classroom Lecture
Learning Objectives	Complies with PLOs 1, 2 and 4 The objective of this course is, • To impart the ability of solving different nonlinear systems through analytical approach • To impart the ability of solving different nonlinear systems through numerical approach as well • To impart the ability of analyzing nonlinear systems through fixed points, phase portrait, linear and nonlinear stability approaches. • To impart the ability of analysing nonlinear system design by identifying subharmonic and superharmonic resonance, Poincare map, Liapnouv exponent. • To impart the ability of identifying Chaos and Factals in engineering systems.
Course Description	This course is designed to fulfil the requirement of designing engineering systems considering the nonlinearity in the system, which is usually ignored in system design. Prerequisite: Dynamics/Engineering Mechanics
Course Outline	Introduction to Nonlinear Dynamical System: Linear vs. nonlinear behavior, Classification of nonlinear Systems, Examples of structural, fluid-mechanical and chemical/biological systems, Existence and uniqueness of solutions. First-order nonlinear systems: Autonomous systems: Equilibrium points, linear systems, invariant sets, linearization, phase diagrams and velocity fields, behavior dependence on parameters, bifurcations of equilibria (saddle-node, pitchfork and transcritical), implicit function theorem. Nonautonomous systems. Second-order nonlinear conservative/nonconservative systems: Phase plane analysis, equilibrium points, linearization, stability, periodic orbits and saddle points, potential function and phase portrait, parameter-dependent conservative systems, local bifurcations, examples of global bifurcations, effect of dissipative forces. First-order system in the plane: General phase plane analysis, linearization, general solution for linear systems, classification of equilibrium points, limit cycles, Bendixon's criterion and Poincare Bendixon theorem. Point mapping techniques, exact transformations, and Poincare mappings. One-dimensional linear and nonlinear mappings: Fixed points, linearization, stability, parameter- dependent mappings, bifurcations. Perturbation and other approximate methods: Introduction to regular and singular perturbation expansions through algebraic and transcendental equations; roots of equations and dependence on parameters. Perturbation method for free oscillations, secular terms,

	frequency dependence on response, Poincare-Lindstedt technique for periodic solutions, Harmonic balance and Fourier series for periodic solutions. Averaging methods, amplitude and frequency estimates, slowly varying amplitude and phase ideas, self-excited oscillations. Multiple time-scale techniques. Forced oscillations, concept of a resonance, oscillations far from resonance, near resonances and strong and weak excitations, response near primary resonance, softening and hardening nonlinearities, Duffing's equation and primary and secondary resonances, forced response of self excited systems near resonance, frequency locking and entrainment. General linear systems with constant and periodic coefficients: Concepts of stability (Lyapunov, Poincare, etc.), stability by linearization, boundedness of solutions, Mathieu's equation, transition curves and periodic solutions for Mathieu-Duffing system. Relaxation oscillations: The van der Pol oscillator. Multi degree of freedom systems: Examples, various types of resonances – external, internal, and combination, etc., response prediction using methods of averaging and multiple scales. Some more on bifurcations, structural stability and chaos. Experimental Demonstration: String ballooning motion. Fun with Cantilever beam of large deformation and other developed models. Electronic Circuit building. Numerical computation with Matlab/Mathematica.
Learning Outcome	Following learning outcomes are expected after going through this course. • Will be able to solve nonlinear system of equations both analytically and numerically. • Will be able to apply the method of multiple scale, perturbation method, harmonic balance for solving a set of nonlinear differential equations. • Will be able obtain the interpretation of nonlinear system behavior over the linear system behavior. • Will be able to identify the Chaos in engineering system and will be able to quantify through various measures. • Will be able to derive and analyse nonlinear system behavior.
Assessment Method	Mid Semester Examination (30%), End Semester examination (50%), Class test & quiz (10%), Assignment (10%)
Suggested Readings: Text Books: 1. Jordan, D. W. and Smith, P.: Nonlinear Ordinary Differential Equations, 3rd Edition, Clarendon Press, Oxford, 1999 ed. 2. Nayfeh, A. H. and Mook, D. T.: Nonlinear Oscillations, Wiley Interscience, New York., 1979 ed. 3. Nayfeh, A. H and Balachandran, B. : Applied Nonlinear Dynamics: Analytical, Computational and Experimental Methods, Wiley, 2008 ed.	

4. Strogatz, S. H. : Nonlinear Dynamics And Chaos: With Applications To Physics,Biology,Chemistry, And Engineering, Westview Press, 2001 ed.
5. Ogorzalek Maciej J.:Chaos and Complexity in Nonlinear Electronic Circuits, WorldScientificSeries on Nonlinear Science Series A, 1997 ed.

Course Number	ME6215
Course Credit	L-T-P-Cr : 3-0-0-3
Course Title	Computer Numerical Controlled Machine Tools
Learning Mode	Classroom Lecture
Learning Objectives	Complies with PLOs 1, 2 and 4 After completion of this course, the student should be able: • To recognize the importance of CNC technology over conventional methods • To learn the fundamentals of CNC machine tools control systems with the help of binary logic circuits and solved numerical • To learn the fundamentals of various electrical and mechanical components of CNC machines with the help solved numerical • To learn about different work and tool holding devices for CNC machines • To write CNC part programming for CNC lathe and milling with the help of solved problems • To learn the fundamentals of writing CNC program for free form surfaces after acquiring knowledge on the mathematical modeling of few contour surfaces with solved numerical • To learn designing of a CNC machine, testing and maintenance
Course Description	This course is designed to introduce the fundamentals of CNC Machine tools to get them accustomed with the control systems used, mechanical and electrical components, work and job holding devices, CNC part programming and design and maintenance of CNC machine tools Prerequisite: NIL
Course Outline	Unit I: An overview of CNC Historical perspective, Introduction to NC/CNC/DNC and its role in FMS and CIMS, Is CNC suitable for mass production, basic elements of CNC machine tools, Machine axes designation, Advantages and disadvantages of CNC machine tools, Use of CNC technology for non-machining applications, CNC machines for industry 4.0 Unit II: Classification of CNC machine tools Point-to-point control (P-T-P), Continuous control, Open-loop control, Closed-loop control, 2 and 3 axes, and 4 and 5 axes CNC machine tools Unit III: Mechanical components of CNC machine tools Drive units of the carriages in CNC machine tools: Recirculating ball screw, Roller screw, Planetary roller screws, Recirculating roller screws Unit IV: Electrical and electronics components of CNC machine tools Power units: Working principle of stepper motors, servo motors, ac servo motors etc.; Encoders: Working principle of incremental, absolute, rotary and linear encoders; Working principle of position down counter (PDC), and decoding logic circuits, Interpolators: linear, circular etc., Digital differential analyzer (DDA) hardware-based linear and curvilinear interpolation Unit V: Tooling for CNC machine tools Tool changing arrangements: manual tool changer, automatic tool changer (ATC), tool turrets, tool magazines: chain magazine, circular magazine, and box magazine Unit VI: Work-holding for CNC machine tools

	Turning center work holding methods, Work holding for machining centers Unit VII: CNC part programming Introduction to part programming, advanced programming features and canned cycles, machining of free-form (3D) surfaces: curved surface geometries, cutter path generation for curved surfaces, CNC program generation using CAM software, Remote operation Unit VIII: Design, testing and maintenance of CNC machine tools Design of CNC machine tools for static, dynamic and thermal loads, Testing and calibration of CNC machine tools for geometric, kinematic and thermal errors, Maintenance and troubleshooting operation, Online inspection features
Learning Outcome	Complies with PLOs 1, 4 and 5 The student will be able to • Apply the knowledge of CNC technology taught in this course to develop laboratory scale CNC system • Apply the knowledge of part programming to manufacture any intricate surfaces using CNC machine tools
Assessment Method	Mid Semester Examination (25%), End Semester examination (50%), Class test & quiz (15%), Assignment and Mini Project (10%)
Suggested Readings: References: [1] CAD/CAM: Computer-Aided Design and Manufacturing, MP Groover, PTR Prentice-Hall, New Jersey [2] CNC machining Technology, Graham T. Smith, Springer Verlag, London [3] Computer Numerical Control Machines and Computer Aided Manufacturing, P Radhakrishnan, New Academic Science Limited, UK [4] Machining and CNC Technology, Michael Fitzpatrick, McGraw Hill [5] Computer Numerical Control of Machine Tools, G.E Thyer, NewNes, 1991 [6] CAD/CAM Theory and Practice, Ibrahim Zeid and R Sivasubramanian, Tata McGraw Hill, New Delhi, 2009.	

Course Number	MH4299
Course Credit	0-0-12-6
Course Title	Mechatronics Project-II
Complies with PLOs 1-5. Course Learning Objective: • This course provides students with an opportunity to apply their theoretical knowledge and practical skills in Mechatronics to a real-world engineering project. • Working in teams of maximum two, students will conceptualize, design, implement, and demonstrate a mechatronic system or device. • Emphasis will be placed on interdisciplinary collaboration, project management, problem-solving, and communication skills. Course Learning Outcome: • Apply principles of Mechatronics to identify and define a project problem or opportunity. • Design and develop a mechatronic system or device to meet specified requirements. • Implement and integrate mechanical, electrical, and software components to build the project prototype. • Test, troubleshoot, and refine the project prototype through iterative design iterations. • Demonstrate the functionality and performance of the project prototype through a formal presentation and documentation. • Work effectively in a team environment, demonstrating communication, collaboration, and leadership skills. • Reflect on the project experience and identify lessons learned for future engineering endeavors. Contents: Introduction to Mini-Project Course and Project Selection; Overview of course objectives, expectations, and deliverables; Project proposal submission and approval process; Team formation and roles assignment; Project Planning and Management; Project scope definition and requirements analysis; Project planning, scheduling, and resource allocation; Risk assessment and mitigation strategies; Conceptual Design and System Specification; Brainstorming and idea generation techniques; System architecture design and component selection; Functional decomposition and system specification development; Detailed Design and Component Integration; Detailed mechanical design and CAD modeling; Electrical circuit design and component layout; Software development and programming for control and interface; Prototype Fabrication and Assembly; Fabrication of mechanical components using machining, 3D printing, etc.; Assembly of electrical and electronic components; Integration of software modules and system calibration Testing, Validation, and Iterative Improvement; Functional testing and validation of individual subsystems; Integration testing and system verification; Iterative design refinement based on test results and feedback; Project Documentation and Presentation; Preparation of project documentation, including design reports, technical drawings, and user manuals; Development of a formal project presentation; Final project demonstration and evaluation	

Suggested Reading

1. Bolton, W. (2015). Mechatronics: Electronic control systems in mechanical and electrical engineering. Pearson Education.

Groover, M. P., & Weiss, M. A. (2016). Mechatronics: Principles and applications. Pearson Education.

Sl. No.	Subject Code	SEMESTER IX	L	T	P	C
1.	ME51XX/ ME61XX	M. Tech. Elective - II	3	0	0	3
2.	ME51XX/ ME61XX	M. Tech. Elective - III	3	0	0	3
3.	ME51XX/ EC51XX	M. Tech. Elective - IV	3	0	0	3
4.	MH5199	Mechatronics Project-III**	0	0	16	8
	TOTAL		9	0	16	17

M. Tech. Elective – II						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	ME6105	Acoustics	3	0	0	3
2.	ME6106	Mobile Robotics	3	0	0	3
3.	ME6107	Digital Manufacturing and Industry 4.0	3	0	0	3

Course Number	ME6105
Course Credit	L-T-P-Cr: 3-0-0-3
Course Title	Acoustics
Learning Mode	Classroom Lecture
Learning Objectives	Complies with PLOs 1, 2 and 4 This course aims to develop an understanding of (a) The basics of the phenomenon of Acoustics (b) Mathematical modelling of the linear phenomenon (c) Application of the models for understanding basic acoustics systems such as Resonators, Filters and Ducts etc. (d) Understanding of Environmental acoustics, Community noise, Architectural noise, Underwater acoustics etc
Course Description	To provide the concepts of acoustics and its applications in wide range of engineering problems. Prerequisite: NIL
Course Outline	Acoustics: Objective-Understanding of Vibration, Sound, Noise. Mathematical basics for Acoustics- PDE, Vectors, divergence (Greens) theorem, Stokes theorem, Signal processing. Development of Wave equation, Helmholtz equation. Acoustic wave equation- Plane waves, Acoustic -Power, Intensity & measurement. Transmission, Absorption and attenuation of sound waves in fluids, Spherical Waves, monopole, dipole, quadropole and piston radiator. Radiation and Reception of Acoustic waves. Active sound control Pipes, Cavities, Waveguides, Resonators, Filters and Ducts- Plane Waves, energy dissipation, finite amplitudes and transmission phenomena, horn radiator, mufflers, silencers Noise, signaldetection, hearings and Speech-Noise spectrum and band level, combining band levels and Tones, Detecting signal in noise, Detection threshold, Ear-Thresholds, Equal loudness level contours, Critical bandwidth, Masking Loudness level, Pitch and frequency Environmental Acoustics- weighted Sound levels, Speech interference, Criteria for Community noise, Highway noise, Aircraft noise rating, Hearing loss, Legislations for Noise control Architectural acoustics, Reverberation time, Sound Absorption materials, Direct and Reverberant Live rooms, Acoustic factors in design Transduction-transducers/transmitters- anti reciprocal, reciprocal. Loudspeakers, Microphones. Introduction to Underwater Acoustics. Use of standards for design.
Learning Outcome	Analysis of Acoustic phenomenon for modeling systems with linear acoustics Understanding and designing systems such as mufflers, resonators, filters, ducts, loudspeakers, microphones etc. Understanding the effect of Acoustics- Community noise, Automotive noise, Architectural acoustics etc
Assessment Method	Mid Semester Examination (30%), End Semester examination (50%), Class test & quiz (10%), Assignment (10%)
Suggested Readings: Text Books: 1.Fundamental of Physical Acoustics, David T Black Stock, John Wiley & Sons, Inc, 2000 2. Noise and Vibration Control Engineering: Principles and Applications Leo L. Beranek,	

JohnWiley & Sons, Inc, 2005
3. Handbook of Noise and Vibration Control edited by Malcolm J. Crocker, John Wiley & Sons,Inc., New York, 2007.

Course Number	ME6106
Course Credit	L-T-P-Cr : 3-0-0-3
Course Title	Mobile Robotics
Learning Mode	Classroom Lecture
Learning Objectives	Complies with PLOs 1, 2 and 4 • This course will present various aspects of design, fabrication, motion planning, and control of intelligent mobile robotic systems. • This course presents computational aspects and practical implementation issues and thereby leads to a well rounded training.
Course Description	This course is designed to introduce students to the concepts of Mobile Robotics. The course will provide theoretical background as well as expose the students to practical aspects of Mobile Robotics. Prerequisite: Engineering Mathematics, Linear Algebra
Course Outline	Robot locomotion: Types of locomotion, hopping robots, legged robots, wheeled robots, stability, manoeuvrability, controllability Mobile robot kinematics and dynamics: Forward and inverse kinematics, holonomic and nonholonomic constraints, kinematic models of simple car and legged robots, dynamics simulation of mobile robots Perception: Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, sensors for mobile robots like global positioning system (GPS), Doppler effect-based sensors, vision based sensors, uncertainty in sensing, filtering Localization: Odometric position estimation, belief representation, probabilistic mapping, Markov localization, Bayesian localization, Kalman localization, positioning beacon systems Introduction to planning and navigation: path planning algorithms based on A-star, probabilistic roadmaps (PRM), Markov Decision Processes (MDP), and stochastic dynamic programming (SDP).
Learning Outcome	After completing this course, the students will be able to design and fabricate a mobile robotic platform and program it to apply learned theoretical concepts in practice.
Assessment Method	Mid Semester Examination, End Semester examination, Class test & quiz, Assignment with simulation and hardware building exercises.
Suggested Readings: Text / Reference Books: [1] R. Siegwart, I. R. Nourbakhsh, "Introduction to Autonomous Mobile Robots", The MIT Press, 2011. [2] Peter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer Tracts in Advanced Robotics, 2011. [3] S. M. LaValle, "Planning Algorithms", Cambridge University Press, 2006. (Available online http://planning.cs.uiuc.edu/) [4] Thrun, S., Burgard, W., and Fox, D., Probabilistic Robotics. MIT Press, Cambridge, MA, 2005. [5] Melgar, E. R., Diez, C. C., Arduino and Kinect Projects: Design, Build, Blow Their Minds, 2012.	

Course Number	ME6107
Course Credit	L-T-P-Cr : 3-0-0-3
Course Title	Digital Manufacturing and Industry 4.0
Learning Mode	Classroom Lecture
Learning Objectives	Complies with PLO 1, 2 and 4 • This course will present various aspects of digital manufacture systems and industry 4.0 with smart and connected business perspective. • This course presents data analytics for digital manufacturing and practical implementation issues for cyber physical systems and thereby leads to a well-rounded training. • This course will also give theoretical and practical knowledge on unmanned aerial vehicle or drone technology, automatic guided vehicles and collaborative robotics essential for industry 4.0
Course Description	This course is designed to discuss t various aspects of digital manufacture systems and industry 4.0 with smart and connected business perspective. The course will describe required tools for cyber physical systems development. This course will also give theoretical and practical knowledge on unmanned aerial vehicle or drone technology, automatic guided vehicles and collaborative robotics essential for industry 4.0 Prerequisite: nil
Course Outline	Digital Manufacturing: theory and industrial applications; Project planning and project management with digital tools; Digital configuration and architecture; Digital manufacturing system modelling, simulation and analysis Industry 4.0: Globalization and emerging issues, the fourth revolution, LEAN production systems, smart and connected business perspective, smart factories; Cyber Physical Systems and next generation sensors; Collaborative platform and product lifecycle management; Augmented Reality and Virtual Reality; Machine Learning and Artificial Intelligence in Manufacturing; Industrial Sensing & Actuation; Industrial Internet Systems Automation and Robotic solution under the umbrella of Industry 4.0: Applications of Unmanned Aerial Vehicles (UAVs), Autonomous Guided Vehicles (AGV); Understanding the application scenarios of UAVs and AGVs for manufacturing; Key components of UAV and AGV - Sensor & Hardware, Understanding of Navigation and Path Planning.
Learning Outcome	After completing this course, the students will be able to develop digital twins of the physical system and program it to apply learned theoretical concepts for implementation of collaborative industry 4.0 platforms in practice.
Assessment Method	Mid Semester Examination, End Semester examination, Class tests, Assignments
Suggested Readings: Reference Books: [1] M.P. Groover, “Automation, Production Systems and Computer Integrated manufacturing”, 4th Edition, Pearson Education (2016) [2] Hamed Fazlollahtabar, Mohammad Saidi-Mehrabad, “Autonomous Guided Vehicles: Methods and Models for Optimal Path Planning”, Springer, 2015. [3] K Kumar, D Zindani and J P Davim, “Digital Manufacturing and Assembly Systems in	

Industry 4.0,” CRC Press, 2019

- [4] J P Davim, “Manufacturing in Digital Industries: Prospects for Industry 4.0”, De Gruyter, 2020
- [5] P. K. Garg, “Introduction To Unmanned Aerial Vehicles,” New Age International Private Limited; First edition, 2020
- [6] S.K., Pal, D. Mishra, A. Pal, S. Dutta, D. Chakravarty, S. Pal, “Digital Twin – Fundamental Concepts to Applications in Advanced Manufacturing”, Springer, 2021

M. Tech. Elective - III						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	ME6103	Continuum Mechanics	3	0	0	3
2.	ME6109	Vehicle Dynamics and Multi-body Systems	3	0	0	3

Course Number	ME6103
Course Credit	L-T-P-C: 3-0-0-3
Course Name	Continuum Mechanics
Pre-requisites	Mechanics of Solids and Mechanics of Fluids
Learning Mode	Classroom lecture
Course Objectives	
Complies with PLOs 1,2 and 4 This course targets students of solid and fluid mechanics, aiming to familiarize them with the fundamentals of continuum mechanics by enhancing their problem-solving skills for engineering problems like structural mechanics, fluid dynamics and heat transfer.	
Course Content	
1. Mathematical Preliminaries Introduction to Tensors: Vectors and second order tensors; Tensor operation; Properties of tensors; Invariants, Eigenvalues and eigenvectors of second order tensors; Tensor fields; Differentiation of tensors; Divergence and Stokes theorem. 2. Kinematics of Deformation Continuum hypothesis, Material (Lagrangian) and Spatial (Eulerian) descriptions of motion, Displacement field, Deformation gradient, Stretch ratios, Polar decomposition of deformation gradient, Velocity gradient, Rate of deformation, Vorticity, Length, area and volume elements in deformed configuration; Material and spatial time derivatives - velocity and acceleration, Cauchy stress tensor, state of stress, concept of first and second Piola-Kirchoff stress tensors. 3. Fundamental Laws in Continuum Mechanics: Material derivatives of Line, Surface and Volume Integrals, Conservation of mass, continuity equation, Conservation of linear and angular momentum, Conservation of energy; Continuum Thermodynamics: Basic laws of thermodynamics; Energy equation; Entropy; Clausius-Duhem inequality. 4. Constitutive Relations and Material Models: Constitutive Assumptions; Ideal Fluids; Elastic Fluids, Hyperelastic Material; Notion of Isotropy; Isothermal Elasticity - Thermodynamic Restrictions, Material Frame Indifference, Material Symmetry; Hooke's law, Stokes problem, Newtonian and Non-Newtonian fluids.	
Learning Outcomes: - The students will understand the various theoretical elements of continuum mechanics, and how these elements apply to solids and fluids. - The students will be able to derive and apply the equations of continuum mechanics in the following areas: stress and strain analysis, deformation, work and energy, theory of elasticity, viscoelasticity, theory of plasticity, fluid mechanics, and the basis for constitutive equations. - The students will be able to use continuum theory descriptions in their research work. Furthermore, it will also be helpful for them to understand research or scientific articles with continuum formulations.	
Assessment Method Mid semester examination, End semester examination, Class test/Quiz, Assignments	
Reference Books	
1. Mase, G. T., and Mase, G. E., Continuum Mechanics for Engineers, CRC Press, 2nd Edition, 1999.	

2. Malvern, L. E., Introduction to the Mechanics of a Continuous Medium, Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1969.
3. Rudnicki, J. W., Fundamentals of Continuum Mechanics, John Wiley & Sons, 2015.
4. Lai, W. M., Rubin, D., and Krempl, E., Introduction to Continuum Mechanics, Butterworth-Heinemann, 4th edition, 2015.
5. Reddy, J.N., An introduction to continuum mechanics, Cambridge University Press, 2013.
6. Jog, C.S., Foundations and applications of mechanics: Volume I: Continuum mechanics, Narosa Publishing House, 2007.

Course Number	ME6109
Course Credit	3-0-0-3
Course Title	Vehicle Dynamics and Multi-body Systems
Learning Mode	Lectures and Simulation tools
Learning Objectives	Complies with PLOs 1, 2 and 4 Understanding the dynamics of a wheeled vehicle, various systems- tires and the mechanics, drive trains, steering, braking and suspension systems. Developing models for handling and stability vehicle. Concepts of rigid body dynamic analysis for enabling modeling of vehicle dynamic systems Prerequisite: Engineering Mechanics/Dynamics or equivalent course
Course Description	Wheeled vehicle dynamics with tire mechanics and effect of various subsystems such as drive trains, steering, suspensions, braking. Stability and safety of the vehicle. Basic concepts of rigid body dynamics which go into the mathematical modeling of the vehicle system.
Course Outline	Introduction to vehicle dynamics: Vehicle coordinate systems; loads on axles of a parked car and an accelerating car. Acceleration performance: Power-limited acceleration, traction-limited acceleration. Tire models: Tire construction and terminology; mechanics of force generation; rolling resistance; tractive effort and longitudinal slip; cornering properties of tire; slip angle; camber thrust; aligning moments. Aerodynamic effects on a vehicle: Mechanics of airflow around the vehicle, pressure distribution, aerodynamic forces; pitching, rolling and yawing moments; crosswind sensitivity. Braking performance: Basic equations for braking for a vehicle with constant deceleration and deceleration with wind-resistance; braking forces: rolling resistance, aerodynamic drag, driveline drag, grade, tire-road friction; brakes, anti-lock braking system, traction control, braking efficiency. Steering systems and cornering: Geometry of steering linkage, steering geometry error; steering system models, neutral steer, under-steer, over-steer, steering ratio, effect of under-steer; steering system force and moments, low speed and high speed cornering; directional stability of the vehicle; influence of front wheel drive. Suspension and ride: Suspension types—solid axle suspensions, independent suspensions; suspension geometry; roll center analysis; active suspension systems; excitation sources for vehicle rider; vehicle response properties, suspension stiffness and damping, suspension isolation, active control, suspension non-linearity, bounce and pitch motion. Roll-over: Quasi-static roll-over of rigid vehicle and suspended vehicle; transient roll-over, yaw-roll model, tripping, use of standards for design. Multi-body systems: Review of Newtonian mechanics for rigid bodies and system of rigid bodies; coordinate transformation between two set of axes in relative motion between one another; Euler angles; angular velocity, angular acceleration, angular momentum etc. in terms of Euler angle parameters; Newton-Euler equations of motion; elementary Lagrangian mechanics: generalised coordinates and constraints; principle of virtual work; Hamilton's principle; Lagrange's equation, generalized forces. Lagrange's equation with constraints, Lagrange's multiplier.
Learning Outcome	Mathematical modeling of the vehicle dynamic system with integrations of various subsystems- Tire, drive trains, suspension, steering, brakes. Understanding of the stability and rollover limits of the vehicle.

	Use of simulation tools for developing the analytical model and also rigid body analysis tools
Assessment Method	Assignments, Quiz, Mid term and end term exams
Suggested Readings: 1. T.D. Gillespie, "Fundamental of Vehicle Dynamics", SAE Press (1995). 2. J.Y. Wong, "Theory of Ground Vehicles", 4th Edition, John Wiley & Sons (2008). 3. Reza N. Jazar, "Vehicle Dynamics: Theory and Application", 1st Edition, Springer (2008). 4. R. Rajamani, "Vehicle Dynamics and Control", Springer (2006). 5. A.A. Shabana, "Dynamics of Multibody Systems", 3rd Edition, Cambridge University Press (2005). Reference Book 1. G. Genta, "Motor Vehicle Dynamics", World Scientific Pub. Co. Inc. (1997). 2. H.B. Pacejka, "Tyre and Vehicle Dynamics", SAE International and Elsevier (2005). 3. Dean Karnopp, "Vehicle Stability", Marcel Dekker (2004). 4. U. Kiencke and L. Nielsen, "Automotive Control System", Springer-Verlag, Berlin. 5. M. Abe and W. Manning, "Vehicle Handling Dynamics: Theory and Application", 1st Edition, Elsevier (2009). 6. L. Meirovitch, "Methods of Analytical Dynamics", Courier Dover (1970). 7. H. Baruh, "Analytical Dynamics", WCB/McGraw-Hill (1999).	

M. Tech. Elective - IV						
Sl. No.	Subject Code	Subject	L	T	P	C
1.	EC5114	Advanced Digital Image Processing	3	0	0	3
2.	EC6104	VLSI Signal Processing	3	0	0	3

Course Number	EC5114
Course Credit	3-0-0-3
Course Title	Opto-Electronics Materials and Devices
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 1 and 2
Course Description	Opto-Electronics Materials and Devices cover the study of materials and devices that interact with light for applications in communication, sensing, and display technologies. The course includes topics such as semiconductor optoelectronics (e.g., LEDs, lasers, photodetectors), optical materials (e.g., semiconductors, polymers), device physics, fabrication techniques, and applications in telecommunications, imaging, solar cells, and optical sensing.
Course Outline	UNIT I ELEMENTS OF LIGHT AND SOLID-STATE PHYSICS Wave nature of light, Polarization, Interference, Diffraction, Light Source, review of Quantum Mechanical concept, Review of Solid-State Physics, Review of Semiconductor Physics and Semiconductor Junction Device. UNIT II DISPLAY DEVICES AND LASERS Introduction, Photo Luminescence, Cathode Luminescence, Electro Luminescence, Injection Luminescence, Injection Luminescence, LED, Plasma Display, Liquid Crystal Displays, Numeric Displays, Laser Emission, Absorption, Radiation, Population Inversion, Optical Feedback, Threshold condition, Laser Modes, Classes of Lasers, Mode Locking, laser applications. UNIT III OPTICAL DETECTION DEVICES Photo detector, Thermal detector, Photovoltaics, Photo Conductors, Sensors, Detector Performance. UNIT IV OPTOELECTRONIC MODULATOR Introduction, Analog and Digital Modulation, Electro-optic modulators, Magneto Optic Devices, Acoustoptic devices, Optical, Switching and Logic Devices. UNIT V OPTOELECTRONIC INTEGRATED CIRCUITS Introduction, hybrid and Monolithic Integration, Application of Opto Electronic Integrated Circuits, Integrated transmitters and Receivers, Guided wave devices.
Learning Outcome	Complies with PLO 1b, 2a and 4a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	Text Books 1. Pallab Bhattacharya “Semiconductor Opto Electronic Devices”, Prentice Hall of India Pvt., Ltd., New Delhi, 2006. 2. Jasprit Singh, “Opto Electronics – As Introduction to materials and devices”, McGraw-Hill International Edition, 1998 Reference Books 1. S C Gupta, Opto Electronic Devices and Systems, Prentice Hal of India,2005. 2. J. Wilson and J.Haukes, “Opto Electronics – An Introduction”, Prentice Hall, 1995.

Course Number	EC6104
Course Credit	L-T-P-C: 3-0-0-3
Course Title	VLSI Signal Processing
Learning Mode	Lectures
Learning Objectives	Complies with Program Goals 1 and 2
Course Description	VLSI Signal Processing involves the design and implementation of signal processing algorithms and systems using Very-Large-Scale Integration (VLSI) technology. The course covers topics such as digital signal processing (DSP) algorithms, efficient hardware implementations, optimization techniques, and applications in areas such as telecommunications, audio processing, image processing, and biomedical signal processing.
Course Outline	Introduction to DSP systems: Representation of DSP algorithms; Iteration Bound: Definition, Examples, Algorithms for computing Iteration bound; Pipelining and Parallel Processing: Definitions, Pipelining and parallel processing of FIR filters, Pipelining and parallel processing for low power; Retiming: Definitions and Properties, Solving system of Inequalities, Retiming techniques; Unfolding: Definition, An algorithm for unfolding, Applications of unfolding; Folding: Definition, Folding transformations, Register minimization techniques, Register minimization in folded architectures; Systolic Architecture Design: Introduction, Systolic array design methodology, FIR systolic arrays, Selection of scheduling vector, Matrix-Matrix multiplication and 2D systolic array design; CORDIC based Implementations: Architecture, Implementation of FIR filter and FFT algorithm; Bit-Level arithmetic architectures: Parallel multipliers, Bit-serial multipliers, Bit-Serial FIR filter design and Implementation; Redundant arithmetic: Redundant number representation, Carry-free radix-2 addition and subtraction, radix-2 hybrid redundant multiplication architectures; Low-power design: Theoretical background, Scaling versus power consumption, Power analysis, Power reduction techniques, Power estimation approaches.
Learning Outcomes	Complies with PLOs 1a, 1b, 2 and 3a
Assessment Method	Quizzes/Assignments, Mid Sem, and End Sem
Suggested Readings	<u>Text/References</u> 1. U. Meyer-Baese, "DSP with FPGA", Springer, 4th Edition, 2014. 2. K. K. Parhi, "VLSI DSP Systems", Wiley, 2003. 3. R.G. Lyons, "Understanding Digital Signal Processing", Pearson Education, 3rd Edition, 2011.