भारतीय सूचना प्रौद्योगिकी संस्थान भागलपुर

INDIAN INSTITUTE OF INFORMATION TECHNOLOGY BHAGALPUR

An Institute of National Importance Under Act of Parliament

2nd Meeting of Board of Academic Programs

for

M.Tech in Electric Vehicle Technology

Dept. of Mechatronics Engineering (MEA)

INDIAN INSTITUTE OF INFORMATION TECHNOLOGY BHAGALPUR

Dept. of Mechatronics Engineering (MEA)

M. Tech.

in

Electric Vehicle Technology

Curriculum

Code	Course Name	L	T	P	C
	1st Semester				
MEA501	Hybrid and Electric Vehicle	3	1	0	4
MEA502	Dynamics and Control of Electric Vehicle	3	0	0	3
MEA503	Automation in Electric Vehicle	3	0	0	3
MEA504	Battery and Charging Technology in EV	3	0	0	3
	Elective -I	3	0	0	3
MEA531	Automation Lab	0	0	3	2
MEA532	Simulation LAB	0	0	3	2
MEA581	Capstone Project – I	0	0	0	1
	Total Semester Credits				21
	2nd Semester				
CS504	Machine Learning	3	0	0	3
MEA505	Electrical Drive	3	1	0	4
MEA506	Battery Management System	3	0	0	3
	Elective -II	3	0	0	3
	Elective -III	3	0	0	3
CS533	Machine Learning Lab	0	0	3	2
MEA533	Battery Management Lab	0	0	3	2
MEA582	Capstone Project – II	0	0	0	1
	Total Semester Credits				21
	3rd Semester				
MEA591	Major Project-I	0	0	0	10
	4th Semester				
MEA592	Major Project-II	0	0	0	14
	Total Program Credits				66

Elective Courses

Code	Course Name	L-T-P-C
MEA551	Finite Element Method	3-0-0-3
MEA552	Modelling and Analysis of Electric Machines	3-0-0-3
MEA553	Computational Fluid Dynamics	3-0-0-3
MEA554	Computer Integrated Manufacturing	3-0-0-3
MEA555	CAD for Electric Vehicle	3-0-0-3
CS502	Artificial Intelligence	3-0-0-3
MA503	Probability and Stochastic Processes	3-0-0-3
EC553	Introduction to IoT	3-0-0-3
EC503	Computational Intelligence	3-0-0-3

Syllabus

Course Code	Course name	L	T	P	C	Year	Semester
MEA501	Hybrid and Electric Vehicle	3	1	0	4	1st	1st
Topic	**Contents**						**No. of Lectures**
Module-I	**Introduction to Vehicle Propulsion and Powertrain Technologies:** History of Vehicle Development, Internal Combustion Engine Vehicles (ICEVs), Vehicles with Alternative Fuels, Powertrain Technologies, Transmission Systems, Drivetrain and Differentials. **Electric and Hybrid Powertrain Technologies:** Introduction, Battery Electric Vehicles (BEVs), Fuel-Cell Electric Vehicles (FCEVs),						10
Module-II	Hybrid Electric Vehicles, Plug-in Hybrid Electric Vehicles (PHEVs), Hybrid Hydraulic Vehicles (HHVs), Pneumatic Hybrid Vehicles (PHVs), Power/Energy Management Systems. **Body and Chassis Technologies and Design:** Introduction, General Configuration of Automobiles, Body and Chassis Fundamentals, Different Types of Structural Systems,						10
Module-III	Body and Chassis Materials, Specific Considerations in Body and Chassis Design of Electric and Hybrid Electric Vehicles, Chassis Systems of Electric and Hybrid Electric Vehicles.						8
Module-IV	**Vehicle Dynamics Fundamentals:** Concepts and Terminology, Vehicle Kinematics, Tire Mechanics and Modeling, ICE Performance Characteristics, Electric Motor Performance Characteristics,						10
Module-V	Battery Performance Characteristics, Transmission and Drivetrain Characteristics, Regenerative Braking Characteristics, Driving Cycles. **Powertrains Components:** Case Study: Introduction, Rechargeable Battery Vehicles, Hybrid Vehicles, Fuel Cell Powered vehicles						10
	Total No. of Lectures						48
Text	1. A. Khajepour, S. Fallah and A. Goodarji, "*Electric and Hybrid Vehicles, Technologies, modeling and control: A mechatronic approach",* 1st edition, Willey, 2014. 2. J. Larminie and J. Lowry, "*Electric vehicle technology explained",* 2nd edition, Wiley, 2012.						
Reference	1. R.N. Jazar, "*Vehicle Dynamics: Theory and Application"*, New York: Springer, 2017.						

Course Code	Course name	L	T	P	C	Year	Semester
MEA502	Dynamics and Control of Electrical Vehicle	3	0	0	3	1st	1st
Topic	**Contents**						**No. of Lectures**
Module-I	Fundamentals of Vehicle Dynamics; Design of Transmission Systems for EVs; Modeling and Analysis of suspension systems; braking and steering systems for EVs						8

Module-II	Stability and Control of EVs; Vehicle Ride; Tire forces and tire modelling of EVs; BEV/ Hybrid System Engineering, System Engineering, SIL, HIL, Component Sizing and Data Analytics, Software & Hardware Control Strategy, EV/ Architecture (HV, LV and CAN)	8
Module-III	Functional Safety standard–ISO 26262, Software Validation and Quality; Design and Integration, Vehicle ECU Programming, Mounting and Installation, Thermal Management; Wiring Harness and Architecture, Harness Architecture and Simulation Tools	8
Module-IV	HV Harness Design, including Connectors, Fuses, Relays and Sensors, LV Harness design, Intra Vehicle Network Design, EMI / EMC compliance; Energy management within the power train architecture	8
Module-V	Controllers in EVs, Axle translational controls, gearbox controllers; SW architecture and AUTOSAR; NVH in electric vehicle; Safety systems, FDSS, Isolation monitoring, HVIL; junction boxes, contactors, relays, fuses: selection, design, component sizing; issues in operating HV contactors – pre-charge circuits, diagnostics,	8
	Total No. of Lectures	40
Text	1. H.Du, D. Cao and H. Zhang, "*Modeling, Dynamics, and Control of Electrified Vehicles*, Woodhead Publishing, 1st edition, 2017 2. P. Wach, *Dynamics and control of Electrical Drive*, 2011	
Reference	1. M. Ehsani, Y.Gao, S.E. Gay and E. Ali, *Modern Electric, Hybrid Electric and Fuel Cell Vehicle Fundamentals, Theory and Design*, CRC press, 1st edition, 2005 2. W. Liu, *"Hybrid Electric Vehicle System Modeling and Control"*, 2nd edition, Willey, 2017	

Course Code	**Course name**	**L**	**T**	**P**	**C**	**Semester**
MEA503	Automation in Electric Vehicle	3	0	0	3	1st
Topic	**Contents**					**No. of Lectures**
Module-I	**Automotive Embedded System Technology:** Overview of Embedded System Categories, Various Embedded Sub Systems like Chassis, Body, Driveline, Engine, Fuel, Emission, Brakes, Suspension, Emission, Brakes, Suspension, Doors, Safety & Security, Comfort & Multimedia, Communication & Lighting and Future Trends in Automotive Embedded Systems: X -by - Wire technologies. **Concept to Market:** Understanding Automotive Product Design Cycle, Microcontroller, architecture, Memory map, I/O map, Building Blocks of Automotive Electronic Product: Actuators, Sensors, Semiconductor Components, Devices, Integrated Circuits (ICs), Relay, Stepper motor, PCBs etc.					08
Module-II	Structure of embedded programme, infinite loop, and compiling, linking and locating, downloading and debugging, Intra processor Communication Protocols: I2C & I2S, SPI & USB, LIN and CAN. Coding Standards and Guidelines: MISHRA C & Automotive Operating System: OSEK/VDX, AUTOSAR.					08
Module-III	**Sensors :** Introduction, Basic Sensor Arrangement, Types of Sensors, Oxygen Sensor, Cranking Sensor, Position Sensor, Engine Oil Pressure Sensor, Linear and Angle Sensor, Flow Sensor, Temperature and Humidity Sensor, Gas Sensor, Speed and Acceleration Sensor, Knock Sensor, Torque					08

	Sensor, Yaw Rate Sensors, Tire Pressure Sensor, Actuators. signal conditioning.	
Module-IV	An Introduction to Internet-of-Things, architectural overview, main design principles and needed capabilities, An IoT architecture outline, standards considerations, M2M and IoT Technology fundamentals Basics of Networking; Communication Protocols, Sensor Networks, Machine to-Machine Communications, Wireless medium access issues, MAC protocol survey, Survey routing protocols, Sensor deployment & Node discovery, Data aggregation & dissemination.	08
Module-V	Sensor Technology, RFID Technology, WPAN Technologies for IoT/ M2M, Cellular and mobile network technologies for IoT/ M2M CoAP, REST, Zigbee, Bluetooth, transport and session layer protocols – TCP, MPTCP, UDP, DCCP, HTTP, CoAP, XMPP, AMQP, MQTT.	08
	Total No. of Lectures	40
Text	1. M. Staron, "*Automotive Software Architectures: An Introduction"*, Springer, 1st edition, 2017. 2. Dieter U, M Harrison and M. Florian, "*Architecture the Internet of Things*, Springer., 2011 3. T. Denton, "*Automotive Electrical and Electronic Systems"*, Taylor and Francis. 5th edition, 2017.	
References:	1. N. Navet and F. Simonot-Lion, "*Automotive Embedded Systems Handbook"*, CRC Press, 1st edition, 2009. 2. R.K.Jurgen, "*Distributed Automotive Embedded Systems*", SAE International, 2007. 3. R. Bosch, "*Automotive Hand Book"*, SAE, 5th edition, 2000.	

Course Code	**Course name**	**L**	**T**	**P**	**C**	**Year**	**Semester**
MEA504	Battery and Charging Technology in EV	3	0	0	3	1st	1st
Topic	**Contents**						**No. of Lectures**
Module-I	Selected energy storage devices and connect with their electric power applications in electric vehicles, energy requirement of vehicles, power requirement of vehicles, sizing of energy storage ratings						**8**
Module-II	Types of batteries Li-Ion, Metal Air Batteries: Aluminum air battery, Zinc air battery, fuel cells, supercapacitors, Hydrogen energy storage;						**8**
Module-III	Fundamental of Battery pack design: Mechanical Design, Thermal Design, Electrical Design						**8**
Module-IV	Charging Infrastructure, Battery Charging : Types of chargers slow and fast, Battery Swapping, Standardization and On board Chargers, public chargers, bulk chargers, swap stations, economics of public chargers.						**8**

Module-V	Difference between charging station and charging point; Inductive charging, Flash Charging; Charger protocols, OCPP, V2G, CHADEMO, Bharat Charger; Impact of charging on grid; Renewable energy integration to chargers; Application of IoT to charging infrastructure.	**8**
	Total No. of Lectures	**40**
Text	1. S. Dhameja, "*Electric Vehicle Battery Systems*, Newnes", 1st edition, 2001. 2. J. G. Hayes and A. Goodarzi, "*Electric Powertrain - Energy Systems, Power electronics and drives for Hybrid, electric and fuel cell vehicles*", Wiley, 1st edition, 2018.	
Reference	1. B. Scrosati, J. Garche and W. Tillmetz, "*Advances in Battery Technologies for Electric Vehicle"*, Woodhead, 1st edition, 2015. 2. K. T. Chau, "*Energy Systems for Electric and Hybrid Vehicles*", The Institution of Engineering and Technology, 2016	

Course Code	**Course Name**	**L**	**T**	**P**	**C**	**Year**	**Semester**
CS504	Machine Learning	3	0	0	3	1st	2nd
Topic	**Content**						**No. of Lectures**
Module I	Introduction: History of machine learning, Basic concepts						5
Module II	Supervised learning: Supervised learning setup, LMS, Logistic regression, Perceptron, Backpropagation, neural networks, Exponential family, Generative learning algorithms, Gaussian discriminant analysis, Naive Bayes, Support vector machines, Model selection and feature selection, Ensemble methods: Bagging, boosting.						10
Module III	Learning theory: Bias/variance trade-off, Union and Chernoff/Hoeffding bounds, VC dimension, Worst case (online) learning.						8
Module IV	Unsupervised learning: Clustering K-means, EM. Mixture of Gaussians, Factor analysis, PCA (Principal components analysis), ICA (Independent components analysis).						9
Module V	Miscellaneous topics: Hypothesis testing, cross-validation, quadratic discriminant Analysis, adaptive hierarchical clustering, gradient boosting.						8
	Total No. of Lectures						40
Text	1. Ethem Alpaydin, "*Introduction to Machine Learning"*, PHI, Third Edition, 2015. 2. Marsland, Stephen. "*Machine learning: an algorithmic perspective"*, Chapman and Hall/CRC, 2nd edition, 2014. 3. Tom Mitchell, "*Machine Learning*", McGraw Hill, First edition 2017.						
Reference	1. Murphy, Kevin, "*Machine Learning: A Probabilistic Perspective (Adaptive Computation and Machine Learning series)"* , The MIT Press; Illustrated edition, 2012. 2. Müller, Andreas C., and Sarah Guido, "*Introduction to machine learning with Python: a guide for data scientists"*, O'Reilly, 1st edition, 2016.						

Course Code	Course name	L	T	P	C	Year	Semester
MEA505	Electrical Drive	3	0	0	3	1st	2nd
Topic	**Contents**						**No. of Lectures**
Module-I	**Fundamental of Electrical Drive** Introduction of Electric Drives, Dynamics of Electric Drives, Four Quadrant Operation, elements of drive system, drive characteristics, criteria for selection of drive components, Equivalent drive parameters, Load equalization, Characteristic of DC Motor.						8
Module-II	**DC and AC Drives** Motor load dynamics, starting, braking & speed control of dc and ac motors. **DC drives:** converter and chopper control. **AC Drives:** Operation of induction and synchronous motors from voltage and current inverters, slip power recovery, pump drives using ac line controller and self-controlled synchronous motor drives.						8
Module-III	**Advance Electric Drives** Introduction, Principle of operation of the chopper, Chopper controlled drives, Duty-ratio control, current-limit control, steady state analysis, four quadrant chopper circuit, chopper for inversion/other power devices, mode & input to the chopper, power factor and ripples in motor current Chopper control of separately excited DC motor and DC series motor.						8
Module-IV	**DC to AC Converter:** Classification of inverter, Single phase and three phase inverters operation using BJTs and MOS devices for VSI and CSI, Basic concept of PWM controlled inverter (for AC drives). **AC to AC Converter:** AC voltage controllers. Single and three-phase Cycloconverter circuits, blocked group operation, circulating current mode operation (for AC drives).						8
Module-V	**CONTROL OF DRIVES** performance and stability of variable speed dc, control of effective rotor resistance, recovery of slip energy, variable frequency control of ac motors, Application: ON-Line & OFF-line UPS, SMPS, Electronic Ballast,						8
						Total No. of Lectures	40
Text	1. G. K. Dubey, "*Fundamentals of Electrical Drives",* Narosa, 2nd edition, 2010 2. W. Shepherd, D. T. W. Liang and L.N. Hulley, "*Power Electronics and Motor Control"*, Cambridge Univ. Press, 2nd edition, 2012						
Reference	1. N. Mohan, "*Power electronics: converters, applications, and design*", Wiley, 3rd edition, 2003.						

Course Code	Course name	L	T	P	C	Year	Semester
MEA506	Battery Management System	3	0	0	3	1st	1st
Topic	**Contents**						**No. of Lectures**
Module-I	**Battery Management system: Introduction** Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel, Electrochemical and lithium-ion cells, Rechargeable cell, Charging and Discharging Process, Overcharge and Undercharge, Modes of Charging						8
Module-II	**Battery Management System Requirement:** Introduction and BMS functionality, Battery pack topology, Voltage Sensing, Temperature Sensing, Current Sensing, BMS Functionality, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation						8
Module-III	**Battery State of Charge and State of Health Estimation, Cell Balancing:** Battery state of charge estimation (SoC), voltage-based methods to estimate SoC, Model-based state estimation, Battery Health Estimation, Lithium-ion aging: Negative electrode, Positive electrode, Cell Balancing, Causes of imbalance, Circuits for balancing						8
Module-IV	**Modelling and Simulation:** Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach, Physics-based modelling approach, Simulating an electric vehicle, Vehicle range calculations, Simulating constant power and voltage, Simulating battery packs						8
Module-V	**Design of BMS:** Design principles of battery BMS, Effect of distance, load, and force on battery life and BMS, energy balancing with multi-battery system						8
	Total No. of Lectures						40
Text	1. V. Pop, H.J. Bergveld, D. Danilov, P.P.L. Regtien, P.H.L Notten, "*Battery management systems: Accurate state-of-charge indication for battery-powered applications*" Springer Science & Business Media, Vol. 9. 2008. 2. H.J. Bergveld, W.S Kruijt., P.H.L Notten, "*Battery Management Systems -Design by Modelling",* Philips Research Book Series; Springer Science & Business Media, 2002. 3. X. Rui, "*Battery Management Algorithm for Electric Vehicles*", Springer, 1st edition, 2020 4. K. T. Chau, "*Energy Systems for Electric and Hybrid Vehicles*", The Institution of Engineering and Technology, 2016.						
Reference	1. G. L. Plett, "*Battery management systems*, Vol. I: Battery modeling", Artech House, 2015. 2. G L Plett, "*Battery management systems*, Vol II: Equivalent-circuit methods", Artech House, 2015.						

ELECTIVES (I, II, III) Syllabus

Course Code	Course name	L	T	P	C	Year	Semester
MEA551	Finite Element Method	3	0	0	3	1st	
Topic	**Contents**						**No. of Lectures**
Module-I	**Introduction:** Historical background, basic concept of the finite element method, solving of axial load problem, beam problem, power of FEM.						6
Module-II	**Variational methods:** calculus of variation, extermination of a function, obtaining the variational form from a differential equation, principle of virtual work, Ritz method, Galerkin Method, Least square method, collocation method, sub domain method, the Rayleigh-Ritz and Galerkin methods.						8
Module-III	**Analysis of 1-D problems:** formulation by different approaches (direct, potential energy and Galerkin); Derivation of elemental equations and their assembly, solution and its post processing. Applications in heat transfer, fluid mechanics and solid mechanics. Bending of beams, analysis of truss and frame						10
Module-IV	**Analysis of 2-D problems:** finite element modelling of single variable problems, triangular and rectangular elements; Applications in heat transfer, fluid mechanics and solid mechanics.						8
Module-V	**Numerical considerations:** Numerical integration, error analysis, mesh refinement. Plane stress and plane strain problems, gradient estimation, Bending of plates, Eigen value and time dependent problems; Discussion about preprocessors,						8
	Total No. of Lectures						40
Text	1. U. S. Dixit, "*Finite Element Method for Engineers"*, Cengage learning India Pvt. Ltd, 2018 2. J. N. Reddy, "*An introduction to the Finite Element Method*, McGraw-Hill", 3rd edition, 2006. 3. R. D. Cook, D. S. Malkus and M. E. Plesha, "*Concepts and Applications of Finite Element Analysis"*, Wiley, 4th edition, 2007.						
Reference	1. T. J. R. Hughes, "*The Finite Element Method*", Prentice-Hall, 1986. 2. O. C. Zienkiewicz and R. L. Taylor, *"The Finite Element Method*, Butterworth-Heinemann", 7th edition, 2013.						

Course Code	Course name	L	T	P	C	Year	Semester
MEA552	Modelling and Analysis of Electric Machines	3	0	0	3	1st	
Topic	**Contents**						**No. of Lectures**
Module-I	Basics of magnetic circuits, Analysis of magnetic circuits with air gap and permanent magnets, Analysis of singly excited electromechanical systems with linear magnetics, Nonlinear magnetics using energy and co-energy principles.						8

Module-II	Inductances of distributed windings - salient pole, cylindrical rotor, Analysis of the doubly excited two-phase rotational system, Reference frames power invariance and non-power invariance.	8
Module-III	Derivation of dc machine systems from the generalized machine, Analysis of induction machine - synchronous reference frame - with currents as variables - with rotor flux as variables.	8
Module-IV	Basis for vector control - small signal modelling of induction machine, V/F Control, Analysis of the alternator - synchronous reference frame.	8
Module-V	Derivation of salient and cylindrical rotor machine phasor diagrams, Three phase short circuit of alternator and various time constants.	8
	Total No. of Lectures	40
Text	1. A. E. Fitzgerald, C. Kingsley, Jr., S. D. Umans, "*Electric Machinery* McGraw- Hill, 6th edition, 2013. 2. D. Kelly, and S. Simmons, "*Introduction to Generalized Machine Theory*". McGraw-Hill, 1968.	
Reference	1. S. J. Chapman, "*Electric Machinery Fundamentals*, McGraw-Hill", 5th edition, 2011.	

Course Code	**Course name**	**L**	**T**	**P**	**C**	**Year**	**Semester**
MEA553	Computational Fluid Dynamics	3	0	0	3	1st	
Topic	**Contents**						**No. of Lectures**
Module-I	**Basic equations of Fluid Dynamics:** General form of a conservation law; Equation of mass conservation; Conservation law of momentum; Conservation equation of energy. The dynamic levels of approximation. Mathematical nature of PDEs and flow equations.						08
Module-II	**Basic Discretization techniques:** Finite Difference Method (FDM); Analysis and Application of Numerical Schemes: Consistency; Stability; Convergence; Fourier or von Neumann stability analysis; Modified equation; Application of FDM to wave, Heat, Laplace and Burgers equations.						10
Module-III	**Integration methods for systems of ODEs**: Linear multi-step methods; Predictor-corrector schemes; ADI methods; The Runge-Kutta schemes. Vorticity-stream function formulation.						08
Module-IV	**Incompressible Navier-Stokes equations:** Solution of Navier-Stokes equations using MAC algorithm. The Finite Volume Method (FVM) and conservative discretization. Numerical solution of the incompressible flow						08

Module-V	**Formulation of Navier-Stokes equations:** Primitive variable formulation; Pressure correction techniques like SIMPLE, SIMPLER and SIMPLEC; Brief introduction to compressible flows and numerical schemes – quick idea of Euler equations, homogenity and flux jacobian. Introduction to upwind schemes.	08
	Total No. of Lectures	42
Text	1. J. C. Tannehill, D. A. Anderson, and R. H. Pletcher, "*Computational Fluid Mechanics and Heat Transfer"*, CRC Press, 3rd edition2011. 2. J. D. Anderson Jr., "*Computational Fluid Dynamics*, McGraw-Hill International Edition", 2017. 3. S.V. Patankar, "*Numerical Heat Transfer and Fluid Flow"*, Hemisphere, 2017. 4. J. H. Ferziger and M. Peric, "*Computational Methods for Fluid Dynamics"*, Springer, 3rd edition, 2002.	
Reference	1. 1. T. J. Chung, "*Computational Fluid Dynamics"*, Cambridge University Press, 2010. 2. C. A. J. Fletcher, "*Computational Techniques for Fluid Dynamics"*, Springer, Vol. 1 and 2, 1998.	

Course Code	**Course name**	**L**	**T**	**P**	**C**	**Year**	**Semester**
MEA554	Computer Integrated Manufacturing	3	0	0	3	1st	
Topic	**Contents**						**No. of Lectures**
Module-I	**Manufacturing Process:** Introduction to CAD and CAM, Manufacturing Planning and control, CIM concepts, Computerized elements of CIM system, Types of manufacturing, Manufacturing models, Manufacturing Control						**08**
Module-II	**Elements of Automation:** Review of automation and control technologies. Material Handling technologies. Data Communication technologies. Automatic Data Acquisition technologies. Database Management technologies.						12
Module-III	**Various Manufacturing Systems:** Group Technology & Cellular Manufacturing Systems, Flexible Manufacturing Systems, Production flow Analysis, Transfer lines, Machine cell design and layout.						8
Module-IV	**Process Planning:** Automated Assembly Systems. Quality Control Systems. Computer-Aided Process Planning. Concurrent Engineering. Production Planning and Control Systems.						6
Module-V	**Integrated manufacturing** Levels of Automation, Lean and Agile Manufacturing. Web-based manufacturing.						6
	Total No. of Lectures						40
Text	1. M. P. Groover, *"Automation production systems, and computer-integrated manufacturing"*, Prentice-Hall of India, 2nd edition, 2001.						

	2. I. Zaid, *Mastering CAD/CAM*, McGraw-Hill Education, 2nd edition, 2006 3. P. Radhakrishnan,S. Subramanyan.and V.Raju, "*CAD/CAM/CIM"*, New Age International (P) Ltd, 2nd edition, 2000.
Reference	1. S.K.Vajpayee, "*Principles of computer-integrated manufacturing"*, Prentice-Hall of India, 2005.

Course Code	Course name	L	T	P	C	Year	Semester
MEA555	CAD for Electric Vehicle	3	0	0	3	1st	
Topic	**Contents**						**No. of Lectures**
Module-I	**Concept of computer aided design and optimization:** Introduction; Computer Aided Design; Explanation of details of flow chart; Input data to be fed into the program; Applicable constraints Max or Minimum permissible limits; Various objective parameters for optimization in an electrical machine; Selection of optimal design; Explanation of lowest cost and significance of "Kg/KVA"; Flowcharts						**8**
Module-II	**Geometry Modelling:** Representation of curves- Hermite curve- Bezier curve- B-spline curves-rational curves-Techniques for surface modeling – surface patch- Coons and bicubic patches- Bezier and B-spline surfaces. Solid modeling techniques- CSG and B-rep – Line-Surface-Solid removal algorithms – shading – colouring – computer animation						**8**
Module-III	**Modes of heat dissipation**; Standard ratings of Electrical machines; Ventilation in rotating machines; Quantity of cooling medium; Types of enclosures; General design procedure; Steps to get optimal design. Application of finite element method in design						**8**
Module-IV	**CAD of DC Machines** Introduction; Flowcharts and programs for computer aided design of DC machines. 2D FEM open source software-based DC machine part design						**8**
Module-V	**CAD of Induction Motor:** Introduction; Flowcharts and programs for computer aided design of Induction motor, 2D FEM open source software-based Induction motor part design COMPUTER AIDED DESIGN OF BLDC, SRM and PMSM motors						**8**
	Total No. of Lectures						**40**
Text	1. K M Vishnu Murthy, "*Computer aided design of electrical machines",* B S Publications, 1st edition, 2008 2. Dr. M. Ramamoorthy. "*Computer- Aided Design of Electrical Equipment*", Affiliated East West press Pvt. Ltd., 2011 3. C.G. Veinott, "*Computer aided design of FHP motors"*, McGraw Hill Pub. Co 4. K. T. Chau, "*Electric Vehicle Machines and Drives: Design, Analysis and Application"*, Wiley, 2015						

Reference	1. S.J Salon, "*Finite Element Analysis of Electrical Machine",*. Springer, YesDEE publishers, Indian reprint, 2007. 2. N. Bianchi, "*Electrical Machine Analysis using Finite Elements"',* CRC Taylor & Francis, 1st edition, 2005 3. A.Saxena and B. Sahay, *Computer Aided Engineering Design* , Springer, 1st edition, 2005

Course Code	**Course name**	**L**	**T**	**P**	**C**	**Year**	**Semester**
CS502	Artificial Intelligence	3	0	0	3	1st	
Topic	**Contents**						**No. of Lectures**
Module-I	Fundamental issues in intelligent systems: History of artificial intelligence; philosophical questions; fundamental definitions; modeling the world; the role of heuristics.						5
Module-II	Search and constraint satisfaction: Problem spaces; brute-force search; best-first search; two-player games; constraint satisfaction.						10
Module-III	Knowledge representation and reasoning: Formal methods (propositional, predicate logic, first order logic), resolution and unification; Informal methods (frames, scripts), answer extraction; knowledge based systems; logic programming, User interface: Human Computer Interaction, User Interface Components, modules of user interface.						8
Module-IV	AI planning systems: Definition and examples of planning systems; planning as search; operator-based planning; propositional planning; planning algorithms.						8
Module-V	Reasoning under Uncertainty and Learning: probabilistic reasoning; Bayes theorem; Introduction to neural networks and reinforcement learning; Case based reasoning, analytical reasoning, model based reasoning,						9
	Total						40
Text	1. Stuart Russell and Peter Norvig, "*Artifical Intelligence: A Modern Approach*", Pearson; 4th Edition , 2020. 2. Elaine Rich, Kevin Knight and Shivashankar B Nair, "*Artificial Intelligence*", Tata McGraw Hill, 3rd Edition 2017. 3. R.B. Mishra, "*Artificial Intelligence*", PHI Learning Pvt. Ltd., 1st edition, 2010.						
Reference	1. N. J. Nilsson, *"Principles of Artificial Intelligence"*, Narosa Publishing House, 2002. 2. Clocksin & Mellish, "*Programming in PROLOG*", Narosa Publ. House, 2002						

Course Code	Course name	L	T	P	C	Semester
MA503	Probability and Stochastic Processes	3	0	0	3	

Topic	Contents	No. of Lectures
Module-I	Axiomatic definitions of probability; conditional probability, independence and Bayes theorem, continuity property of probabilities.	8
Module-II	Random variable: probability, density and mass functions, functions of a random variable; expectation, characteristic, and moment-generating functions; Chebyshev, Markov and Chernoff bounds;	8
Module-III	Jointly distributed random variables: joint distribution and density functions, joint moments, conditional distributions and expectations, functions of random variables; random vector- mean vector and covariance matrix, Gaussian random vectors; Sequence of random variables: almost sure and mean-square convergences, convergences in probability and in distribution, laws of large numbers, central limit theorem;	8
Module-IV	Random process: probabilistic structure of a random process; mean, autocorrelation and autocovariance functions; stationarity - strict- sense stationary and wide-sense stationary (WSS) processes: time averages and ergodicity; spectral representation of a real WSS process-power spectral density, cross-power spectral density,	8
Module-V	Linear time-invariant systems with WSS process as an input- time and frequency domain analyses; examples of random processes: white noise, Gaussian, Poisson and Markov processes.	8
	Total No. of Lectures	40

Text	1. H. Stark and J. W. Woods, *Probability and Random Processes with Applications to Signal Processing*, Pearson, 3rd Edition, 2002. 2. A. Papoulis and S. U. Pillai, *Probability, Random Variables and Stochastic Processes*, McGraw-Hill, 4th Edition, 2017.
Reference	1. B. Hajek, *An Exploration of Random Processes for Engineers*, Cambridge University Press , 2015. 2. Sheldon M Ross, *Stochastic Processes*, Wiley , 2nd Ed, 2016.

Course Code	Course name	L	T	P	C	Semester
EC553	Introduction to IoT	3	0	0	3	

Topic	Contents	No. of Lectures
Module-I	An Introduction to Internet-of-Things, architectural overview, main design principles and needed capabilities, An IoT architecture outline, standards considerations, M2M and IoT Technology fundamentals	8
Module-II	State of art, reference model and architecture, IoT reference architecture, functional view, Deployment and Operational view, other relevant architectural views.	8
Module-III	Sensing, transducers classification, Actuation, Smart sensors, Basics of Networking; Communication Protocols, Sensor Networks, Machine to-Machine Communications, Wireless medium access issues, MAC protocol survey, Survey routing protocols, Sensor deployment & Node discovery, Data aggregation & dissemination.	8
Module-IV	Sensor Technology, RFID Technology, WPAN Technologies for IoT/ M2M, Cellular and mobile network technologies for IoT/ M2M CoAP, REST, Zigbee, Bluetooth, transport and session layer protocols – TCP, MPTCP, UDP, DCCP, HTTP, CoAP, XMPP, AMQP, MQTT	8
Module-V	Developing IoTs, Introduction to Python, Introduction to different IoT tools, developing applications through IoT tools, developing sensor-based application through embedded system platform, Integration of Sensors and Actuators with Arduino, Implementing IoT concepts with python; Domain specific applications of IoT: Home automation, Industry applications, Surveillance applications, other IoT applications.	8
	Total No. of Lectures	40

Text	1. J. Holler, V. Tsiatsis, C. Mulligan, S. Avesand, S. Karnouskos, D. Boyle, *From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence*, Academic Press, 1st edition, 2014. 2. A. Bahga, V. Madisetti, *Internet of Things: A Hands-on Approach*, Universities Press, 1st edition, 2015. 3. P. Raj, Anupama C. Raman, *The Internet of Things: Enabling Technologies, Platforms, and Use Cases*, CRC Press, 1st edition, 2017.
Reference	1. O. Hersent, D. Boswarthick, O. Elloumi, *The Internet of Things: Key Applications and Protocols*, Wiley Press, 2nd edition, 2012. 2. D. Uckelmann, M. Harrison, F. Michahelles, *Architecting the Internet of Things*, Springer, 1st edition, 2011.

Course Code	Course name	L	T	P	C	Semester
EC503	Computational Intelligence	3	0	0	3	

Topic	Contents	No. of Lectures
Module-I	**Introduction to Computational Intelligence:** Intelligence machines, Computational intelligence paradigms, Soft computing constituents and conventional Artificial intelligence, Neuro-Fuzzy and soft computing characteristics	7
Module-II	**Rule-Based Expert Systems and Fuzzy Expert Systems:** Rule-based expert systems, Uncertainty management, Fuzzy sets and operations of fuzzy sets, Fuzzy rules and fuzzy inference, Fuzzy expert systems, Case study: fuzzy logic controller for various applications	9
Module-III	**Artificial Neural Networks:** Fundamental neuro-computing concepts: artificial neurons, activation functions, Neural network architectures, learning rules, Supervised learning neural networks: multi-layer feed forward neural networks, simple recurrent neural networks, time delay neural networks, supervised learning algorithms, Back propagation algorithm, Radial basis function networks Unsupervised learning neural networks, self-organizing feature maps, Deep neural networks and learning algorithms	9
Module-IV	**Evolutionary techniques**: Genetic Algorithm, Evolutionary computation**:** Chromosomes, fitness functions, and selection mechanisms, Genetic algorithms: crossover and mutation, Genetic programming, Evolution strategies, PSO, ACO, BFO	9
Module-V	**Hybrid Intelligent Systems:** Neural expert system, neuro-fuzzy systems, Evolutionary neural network, case study of Neuro-fuzzy based systems.	7
	Total No. of Lectures	**40**

Text	1. S. Rajasekaran, G. A. Vijayalaksmi Pai, *Neutral Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications*, PHI Learning, 2nd edition, 2017. 2. J. S .R. Jng, C. T. Sun, E. Mizutani, *Neuro-Fuzzy and Soft Computing*, Pearson Education, 1st edition, 2015. 3. S. N. Deepa, S. N. Sivanandam, *Principles of Soft Computing*, John Wiley, 3rd edition, 2018.
Reference	1. Timothy J. Ross, *Fuzzy logic with Engineering Applications*, McGraw-Hill, 3rd edition,2011. 2. Simon Haykin, *Neural Networks: A Comprehensive Foundation*, Pearson, 3rd edition, 2009.