B.E. – MECHANICAL ENGINEERING

PROFESSIONAL ELECTIVE -VERTICALS

(REGULATIONS 2019-V21)

CHOICE BASED CREDIT SYSTEM

(Applicable to the students admitted from the Academic Year 2021-22 onwards)

EASWARI ENGINEERING COLLEGE

(Autonomous Institution)
Bharathi Salai, Ramapuram, Chennai - 600 089

[A Unit of SRM Group of Educational Institutions, Approved by AICTE | Affiliated to Anna University, Chennai | NAAC Accredited 'A' Grade | 2(f) & 12(B) Status (UGC) | ISO 9001:2015 Certified | NBA Accredited Programmes | FIST Funded (DST) | SIRO Certified (DSIR)]

EASWARI ENGINEERING COLLEGE

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BE – MECHANICAL ENGINEERING

Vertical I	Vertical II	Vertical III	Vertical IV	Vertical V	Vertical VI	Vertical VII
MANUFACTURING	**DESIGN**	**THERMAL ENGINEERING**	**FLUIDS ENGINEERING**	**CLEAN AND GREEN ENERGY TECHNOLOGIES**	**ROBOTICS AND AUTOMATION**	**DIVERSIFIED GROUP**
191MEE011T: Advances in Casting and Welding processes	**191MEE012T:** Computer Aided Design	**191MEE013T:** Refrigeration and Air conditioning	**191MEE014T:** Hydraulics and pneumatics	**191MEE015T:** Equipment for pollution control	**191MEE016T:** Sensors and Instrumentation	**191MEE017T:** Professional Ethics
191MEE021T: Quality Control and Reliability Engineering	**191MEE022T:** Vibration and noise Control	**191MEE023T:** Gas dynamics and jet propulsion	**191MEE024T:** Fluids Engineering	**191MEE025T:** Energy Conservation and Management	**191MEE026T:** Machine Learning for Intelligence systems	**191MEE027T:** Engineering Economics and Financial Accounting
191MEE031T: Maintenance Engineering	**191MEE032T:** Mechanics of Composite Materials	**191MEE033T:** Thermal power systems	**191MEE034T:** Computational Fluid Dynamics	**191MEE035T:** Environmental sustainability and impact analysis	**191MEE036T:** Industrial Robotics	**191MEE037T:** Operations Research
191MEE041T: Computer Integrated Manufacturing	**191MEE042T:** Vehicle design engineering	**191MEE043T:** Waste Heat recovery systems	**191MEE044T:** Hydro dynamics	**191MEE045T:** Building Automation Systems	**191MEE046T:** IOT for Mechanical Engineering	**191MEE047T:** Process planning and Cost Estimation
191MEE051T: Failure analysis and NDT techniques	**191MEE052T:** Ergonomics in Design	**191MEE053T:** Cryogenic Engineering	**191MEE054T:** Micro fluidics	**191MEE055T:** Hybrid and electrical vehicle technology	**191MEE056T:** Drone Technology	**191MEE057T:** Supply chain management and logistics
191MEE061T: Additive Manufacturing	**191MEE062T:** Industrial layout design and safety	**191MEE063T:** Combustion Engineering	**191MEE064T:** Bio fluid mechanics	**191MEE065T:** Solar Technologies	**191MEE066T:** Electrical Drives and Actuators	**191MEE067T:** Entrepreneurship Development

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE011T	**ADVANCES IN CASTING AND WELDING PROCESSES**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: Manufacturing Technology-I

COURSE OBJECTIVES:	
1.	To elaborate gating system design and metallurgy.
2.	To provide knowledge on Special casting processes
3.	To impart knowledge on Metallurgy of welding
4.	To be acquainted with Special welding processes
5.	To familiarize the students with automation and environmental aspects of welding and casting

UNIT	**TITLE**	**PERIODS**
1	**CASTING DESIGN**	**9**
Introduction - Solidification shrinkage- Pattern allowances- Design of gating System-Design of thin and unequal sections -Rapid solidification processing (RSP) - Melt spinning -Roll quenching - Vibratory solidification -Splat cooling - Thixoforming – Rheocasting - Single crystal growing, Casting defects, inspection, diagnosis and rectification – Case study on casting design		
UNIT	**TITLE**	**PERIODS**
2	**SPECIAL CASTING PROCESSES**	**9**
Evaporative Pattern Casting Process and full mould process – Vaccum sealed moulding - vacuum casting - Magnetic Moulding - Squeeze Casting-types - Plaster mould casting - Ceramic mould casting- Investment casting - Shell Moulding - Continuous casting - Electro slag casting.		
UNIT	**TITLE**	**PERIODS**
3	**WELDING DESIGN**	**9**
Introduction - Fusion zone – Heat flow in welding -Weld solidification --Weldability of steels - Cast iron - Stainless steels, aluminum, copper and titanium alloys - Pre and Post weld heat treatments - Weld joint design- residual stress - Testing of Welding joints -Weld defects – Case study on welding design.		
UNIT	**TITLE**	**PERIODS**
4	**SPECIAL WELDING PROCESSES**	**9**
Principles, Equipment, Types, Advantages and Limitations of High frequency induction welding, Diffusion bonding, Cold pressure welding, Friction welding, Explosive welding, Plasma arc welding, Ultrasonic welding, Electron beam welding and Laser beam welding.		
UNIT	**TITLE**	**PERIODS**
5	**AUTOMATION AND ENVIRONMENTAL ASPECTS OF WELDING AND CASTING**	**9**
Mechanization and automation in foundries: Sand Plant, Material Handling, Mould and Core Making-Pollution control, energy and waste management in foundries. Automated welded joint- Welding robots, Positioners and Manipulators -Microprocessor based control of resistance and arc welding- Arc sensing,		

Weld Seam Tracking and Vision system Effects of welding fumes on environment

	TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Use design knowledge to produce quality casting.
CO2:	Select suitable casting process for the given applications
CO3:	Use design knowledge to overcome defects in welding
CO4:	Select suitable welding process for the given applications
CO5:	Implement automation principles with environment consciousness techniques in welding and casting plants

TEXT BOOKS:	
1.	Lal.M. and Khanna.O.P."A Text Books of foundry technology", DhanpatRai& Sons, 2012.
2.	Jain p L, "Principles of Foundry Technology", Tata McGraw Hill, 2009.

REFERENCE BOOKS:	
1.	American Welding Society,"Welding Handbook", Volume 1-5, 9th Edition, 2001.
2.	Dieter Radaj, "Design and Analysis of Fatigue Resistant Welded Structures", Woodhead Publishing, United Kingdom, 1990, ISBN: 978-1855730045
3.	John Campbell, "Complete Casting Handbook: Metal Casting Processes, Metallurgy, Techniques and Design", 2nd edition, Butterworth-Heinemann., United Kingdom, 2015, ISBN: 978-1856178099
4.	Mahi Sahoo and Sam Sahu, "Principles of Metal Casting", McGraw-Hill Education, United States, 3 rd Edition, 2014, ISBN: 978-0071789752.
5.	Robert B. Tuttle, "Foundry Engineering: The Metallurgy and Design of Castings", Create Space Independent Publishing Platform, Amazon, 2012, ISBN: 9781478157434.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE012T	**COMPUTER AIDED DESIGN**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To provide an overview of how computers are being used in mechanical component design
2.	To understand the various geometric modeling concepts.
3.	To identify the common visual realism algorithms
4.	To impart the knowledge on parts assembly logics and consideration factors
5.	To study the available data exchange formats for CAD model transportation

UNIT	TITLE	PERIODS
1	**FUNDAMENTALS OF COMPUTER GRAPHICS**	**9**
Product cycle- Design process- sequential and concurrent engineering- Computer aided design – CAD system architecture- Computer graphics – co-ordinate systems- 2D and 3D transformations- homogeneous coordinates - Line drawing -Clipping- viewing transformation		
UNIT	**TITLE**	**PERIODS**
2	**GEOMETRIC MODELLING**	**9**
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		
UNIT	**TITLE**	**PERIODS**
3	**VISUAL REALISM**	**9**
Hidden – Line-Surface-Solid removal algorithms – shading – colouring – computer animation		
UNIT	**TITLE**	**PERIODS**
4	**ASSEMBLY OF PARTS**	**9**
Assembly modelling – interferences of positions and orientation – tolerance analysis-mass property calculations – mechanism simulation and interference checking.		
UNIT	**TITLE**	**PERIODS**
5	**CAD STANDARDS**	**9**
Standards for computer graphics- Graphical Kernel System (GKS) - standards for exchange images- Open Graphics Library (OpenGL) - Data exchange standards - IGES, STEP, CALS etc. - communication standards.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Interpret the 2D and 3D transformation methods used in computer graphics
CO2:	Create complex parts using surface and solid modeling techniques
CO3:	Apply the concepts of colour and shading models for product visualization
CO4:	Perform dimensional and mass property analysis using a coordinate system
CO5:	Use the different types of Standard systems used in CAD.

TEXT BOOKS:	
1.	Ibrahim Zeid, R Sivasubramanian, CAD/CAM, Theory and Practice, Second edition, Tata McGraw-Hill Publishing Co.2017
2	Srinivas, J, CAD/CAM Principles and applications, Oxford University Press, 2017

REFERENCE BOOKS:	
1.	Chris McMahon and Jimmie Browne “CAD/CAM Principles", "Practice and Manufacturing management “Second Edition, Pearson Education, 1999.
2.	Ibrahim Zeid, Mastering CAD/CAM, Tata McGraw-Hill Publishing Co.2017
3.	Foley, Wan Dam, Feiner and Hughes - "Computer graphics principles & practice" Pearson Education - 2003.
4.	William M Neumann and Robert F.Sproul “Principles of Computer Graphics”, McGraw Hill Book Co. Singapore, 1989.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE013T	**REFRIGERATION AND AIR CONDITIONING**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: 191MEC403T – Thermal Engineering

COURSE OBJECTIVES:	
1.	To understand the underlying principles of operations in different Refrigeration & Air conditioning systems and components.
2.	To gain knowledge in vapor compression refrigeration system and components associated with it.
3.	To provide knowledge in various non conventional refrigeration systems.
4.	To gain knowledge in psychrometric processes and properties.
5.	To provide knowledge on design aspects of Refrigeration & Air conditioning systems

UNIT	TITLE	PERIODS
1	**INTRODUCTION**	**9**
Introduction to Refrigeration - Unit of Refrigeration and C.O.P.– Ideal cycles -Block diagram of refrigerator & heat pump. Refrigerants Desirable properties – Classification - Nomenclature - ODP & GWP.		
UNIT	**TITLE**	**PERIODS**
2	**VAPOUR COMPRESSION REFRIGERATION SYSTEM**	**9**
Vapor compression cycle: p-h and T-s diagrams - deviations from theoretical cycle – subcooling and super heating- effects of condenser and evaporator pressure on COP- multipressure system - low temperature refrigeration - Cascade systems – problems. Equipments: Type of Compressors, Condensers, Expansion devices, Evaporators.		
UNIT	**TITLE**	**PERIODS**
3	**OTHER REFRIGERATION SYSTEMS**	**9**
Working principles of Vapour absorption systems and adsorption cooling systems – Steam jet refrigeration- Thermoelectric refrigeration- Air refrigeration - Magnetic - Vortex and Pulse tube refrigeration systems. Three fluid system (Electrolux refrigeration), comparison between VCR and VAR.		
UNIT	**TITLE**	**PERIODS**
4	**PSYCHROMETRIC PROPERTIES AND PROCESSES**	**9**
Properties of moist air-Gibbs Dalton law, Specific humidity, Dew point temperature, Degree of saturation, Relative humidity, Enthalpy, Humid specific heat, Wet bulb temperature Thermodynamic wet bulb temperature, Psychrometric chart; Psychrometric of air-conditioning processes, mixing of air streams.		
UNIT	**TITLE**	**PERIODS**
5	**AIR CONDITIONING SYSTEMS AND LOAD ESTIMATION**	**9**
Air conditioning loads: Outside and inside design conditions; Heat transfer through structure, Solar radiation, Electrical appliances, Infiltration and ventilation, internal heat load; Apparatus selection; fresh air load, human comfort & IAQ principles, effective temperature & chart, calculation of summer & winter air conditioning load;		

Classifications, Layout of plants Classification of ductsflow through duct, pressure losses in duct (friction losses, dynamic losses), methods of duct system design cooling and adiabatic mixing. Simple Applications
Case studies: Design And Analysis of Solar Electrolux Vapour Absorption Refrigeration System. Air Conditioning of Classrooms in Schools & Training Centers. Low Power Vapour Compression Refrigeration System.

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Elucidate the principles of Refrigeration and calculation of basic performance parameters.
CO2:	Analyze the performance of vapour compression refrigeration system by calculating the performance parameters.
CO3:	Enumerate the functioning and features of non conventional refrigeration systems
CO4:	Estimate the psychometric properties of gas mixtures, moist air for basic processes.
CO5:	Design HVAC system for a given simple building layout.

TEXT BOOKS:	
1.	Arora, C.P., "Refrigeration and Air Conditioning", 3rd edition, McGraw Hill, New Delhi, 2010
2.	Khurmi R.S, Gupta J.K, “A Textbook of Refrigeration and Air Conditioning” , S Chand Publishing.

REFERENCE BOOKS:	
1.	ASHRAE Hand book, Fundamentals, 2010.
2.	Jones W.P., "Air conditioning engineering", 5th edition, Elsevier Butterworth-Heinemann, 2007
3.	Roy J. Dossat, "Principles of Refrigeration", 4 th edition, Pearson Education Asia, 2009.
4.	Stoecker, W.F. and Jones J. W., "Refrigeration and Air Conditioning", McGraw Hill, New Delhi, 1986.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE014T	**HYDRAULICS AND PNEUMATICS**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: 191MEC302T – FLUID MECHANICS AND MACHINERY

COURSE OBJECTIVES:	
1.	To enable the students, understand the basics of hydraulics and pneumatics.
2.	To teach students about the utilization of cylinders, accumulators, valves and various electrical and electronic control components.
3.	To provide student with knowledge on the application of fluid power in process, construction and manufacturing Industries.
4.	To develop a measurable degree of competence in the design, construction and operation of fluid power circuits.
5.	Introduce students to fluid power condition monitoring, maintenance and troubleshooting.

UNIT	TITLE	PERIODS
1	**FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS**	**9**
Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – Basics of Hydraulics – Pascal's Law – Principles of flow - Friction loss – Work, Power and Torque Problems, Sources of Hydraulic power : Pumping Theory– Pump Classification – Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of Linear and Rotary – Fixed and Variable displacement pumps – Problems.		
UNIT	**TITLE**	**PERIODS**
2	**HYDRAULIC ACTUATORS AND CONTROL COMPONENTS**	**9**
Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Hydraulic motors - Control Components: Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Servo and Proportional valves – Applications – Accessories: Reservoirs, Pressure Switches – Applications – Fluid Power ANSI Symbols – Problems.		
UNIT	**TITLE**	**PERIODS**
3	**HYDRAULIC CIRCUITS AND SYSTEMS**	**9**
Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double- Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail-Safe, Speed Control, Hydrostatic transmission, Electro hydraulic circuits, Mechanical hydraulic servo systems.		
UNIT	**TITLE**	**PERIODS**
4	**PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS**	**9**
Properties of air – Perfect Gas Laws – Compressor – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit – Cascade method – Electro Pneumatic System – Elements – Ladder diagram – Problems, Introduction to fluidics and pneumatic logic circuits.		
UNIT	**TITLE**	**PERIODS**

5	TROUBLE SHOOTING AND APPLICATIONS	9
Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for Pick and Place applications and tool handling in CNC Machine tools – Low-cost Automation – Hydraulic and Pneumatic power packs.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Select an appropriate hydraulic pump for industrial applications.
CO2:	Choose suitable fluid power elements for simple applications.
CO3:	Design a hydraulic circuit for a given simple industrial applications.
CO4:	Design a pneumatic and electro pneumatic system for simple industrial automation.
CO5:	Troubleshoot fluid power systems and applications.

TEXT BOOKS:	
1.	Anthony Esposito, Fluid Power Systems,: Pearson New International edition, 2013.
2.	James R. Daines, Hydraulics and Pneumatics, 2ndEdition, The Good heart-Willcox Company, Inc., 2013.
3.	W.Bolton, Mechatronics, Electronic control systems in Mechanical and Electrical Engineering, Perason Education, 2013.

REFERENCE BOOKS:	
1.	Andrew Parr, Hydraulics and Pneumatics, Butterworth and Heinmann, 2011.
2.	Festo, Basic Pneumatic, Electro pneumatic, Hydraulic text and work books, 2015..
3.	Majumdar S.R., “Oil Hydraulics Systems- Principles and Maintenance”, Tata McGraw-Hill, 2001.
4	John Pippenger and Tyler Hicks, Industrial Hydraullics, McGraw Hill International edition 1980

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE015T	**EQUIPMENT FOR POLLUTION CONTROL**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES:

COURSE OBJECTIVES:	
1.	To study the pollution control regulation and standards, water and wastewater.
2.	To study the equipment for various water pollution.
3.	To study the equipment for air pollution control.
4.	To study the equipment for solid waste processing
5.	To study the pollution monitoring equipment

UNIT	TITLE	PERIODS
1	**POLLUTION CONTROL REGULATIONS AND STANDARDS**	**9**

Pollutants in water and wastewater – sources and impacts- Characteristics and impacts of solid and hazardous wastes - Indian Constitution and Environmental Protection Legislations - Environmental Standards under different Environmental legislations - Water Act (1974), Air Act (1981), Environmental Protection Act (1986) and major Notifications, Municipal solid Wastes (Management and Handling) Rules -Bio Medical Wastes (Management and Handling) Rules - Hazardous Wastes (Management and Handling Rules),Environment Impact Assessment Notifications - Unit operations and unit processes in Pollution Control- - Selection criteria for Pollution Control Equipment.

UNIT	TITLE	PERIODS
2	**EQUIPMENT FOR WATER POLLUTION CONTROL**	**9**

Operational principles and Design criteria of Flash mixers, Flocculators, Clarifiers, Sand Filters, Adsorption Columns, Aerators, Air blowers, Distillation units, Centrifugal and Reciprocating Pumps, Chemical dosing systems, Motors, Pipes, valves and Fittings.- Filed visit to a wastewater treatment plant

UNIT	TITLE	PERIODS
3	**EQUIPMENT FOR AIR POLLUTION CONTROL**	**8**

Operational principles and Design criteria of Cyclone separators, gravity settlers, Wet Scrubbers, Air strippers, Bag Filters, Electrostatic precipitators, Biofilters - Filed visit to an industry with air pollution control systems

UNIT	TITLE	PERIODS
4	**EQUIPMENT FOR SOLID WASTE PROCESSING**	**10**

Operational principles and Design criteria of Dewatering equipment – centrifuge, Vaccum Filter, Filter Press- Size Reduction equipment – shredders, grinders – Trommel and Disc Screens – Air Classifiers- bailing and briquetting – incinerators –Pyrolysis – field visit to a solid

waste processing facility		
UNIT	**TITLE**	**PERIODS**
5	**POLLUTION MONITORING EQUIPMENT**	**9**
Equipment's for sampling of water, solids and air- Sample preservation Equipment – incubators – Cold Storage systems- equipment for analysis of water and air samples- Ambient air and flue gas sampling and monitoring equipment		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Explain the different types of pollution, their sources and effects.
CO2:	Discuss the pollution control regulations and standards
CO3:	Design equipment for pollution control
CO4:	Discuss different methods of pollution control from various sources in air, water and soil
CO5:	Discuss the Conduct performance assessment of pollution control equipment.

TEXT BOOKS:	
1.	George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, "Integrated Solid Waste Management, Mc-Graw Hill India, First edition, 2015.
2.	Rao. C.S (2006)., "Environmental Pollution and Control Engineering", 2nd Edition, Revised, Wiley Eastern Limited, India.

REFERENCE BOOKS:	
1.	Shyam Diwan and Armin Rosencranz, Environmental Law and Policy in India, Oxford, 2001
2.	Metcalf & Eddy, INC, „Wastewater Engineering – Treatment and Reuse, Fourth Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2014.
3.	Noel de Nevers, "Air Pollution Control Engg", Mc Graw Hill, New York, 2016.
4.	CPCB (2021), "Pollution Control Acts, Rules and Notifications issued thereunder, PCL Series- Central Pollution Control Board, Delhi
5.	CPHEEO, "Manual on Municipal Solid waste management, Vol I, II and III, Central Public Health and Environmental Engineering Organization , Government of India, New Delhi, 2016.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE016T	**SENSORS AND INSTRUMENTATION**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES:

COURSE OBJECTIVES:	
1.	To understand the concepts of measurement technology.
2.	To learn the various sensors used to measure various physical parameters.
3.	To learn the fundamentals of signal conditioning, data acquisition and communication systems used in mechatronics system development
4.	To learn about the optical, pressure and temperature sensor
5.	To understand the signal conditioning and DAQ systems

UNIT	**TITLE**	**PERIODS**
1	**INTRODUCTION**	**9**
Basics of Measurement – Classification of errors – Error analysis – Static and dynamic characteristics of transducers – Performance measures of sensors – Classification of sensors – Sensor calibration techniques – Sensor Output Signal Types.		
UNIT	**TITLE**	**PERIODS**
2	**MOTION, PROXIMITY AND RANGING SENSORS**	**9**
Motion Sensors – Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn, Accelerometer – GPS, Bluetooth, Range Sensors – RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor (LIDAR).		
UNIT	**TITLE**	**PERIODS**
3	**FORCE, MAGNETIC AND HEADING SENSORS**	**8**
Strain Gage, Load Cell, Magnetic Sensors –types, principle, requirement and advantages: Magneto resistive – Hall Effect – Current sensor Heading Sensors – Compass, Gyroscope, Inclinometers.		
UNIT	**TITLE**	**PERIODS**
4	**OPTICAL, PRESSURE AND TEMPERATURE SENSORS**	**10**
Photo conductive cell, photo voltaic, Photo resistive, LDR – Fiber optic sensors – Pressure – Diaphragm, Bellows, Piezoelectric – Tactile sensors, Temperature – IC, Thermistor, RTD, Thermocouple. Acoustic Sensors – flow and level measurement, Radiation Sensors - Smart Sensors - Film sensor, MEMS & Nano Sensors, LASER sensors.		
UNIT	**TITLE**	**PERIODS**
5	**SIGNAL CONDITIONING AND DAQ SYSTEMS**	**9**

Amplification – Filtering – Sample and Hold circuits – Data Acquisition: Single channel and multi- channel data acquisition – Data logging - applications - Automobile, Aerospace, Home appliances, Manufacturing, Environmental monitoring.

	TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	**Recognize with various calibration techniques and signal types for sensors.**
CO2:	Describe the working principle and characteristics of force, magnetic, heading, pressure and temperature, smart and other sensors and transducers.
CO3:	Apply the various sensors and transducers in various applications
CO4:	Select the appropriate sensor for different applications.
CO5:	Acquire the signals from different sensors using Data acquisition systems.

TEXT BOOKS:	
1.	Product Lifecycle Management for a Global Market, Springer; 2014 edition (29 September 2016),ISBN-10 : 3662516330
2.	Product LifeCycles and Product Management, Praeger Publishers Inc (27 March 1989)ISBN-10 :0899303196

REFERENCE BOOKS:	
1.	AnttiSaaksvuori and AnselmiImmonen, “Product Lifecycle Management”, Springer Publisher, 2008 (3rd Edition)
2.	IvicaCrnkovic, Ulf Asklund and AnnitaPerssonDahlqvist, “Implementing and Integrating Product Data Management and Software Configuration Management”, Artech House Publishers, 2003.
3.	John Stark, “Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question”, Springer Publisher, 2007
4.	John Stark, “Product Lifecycle Management: 21st Century Paradigm for Product Realisation”, Springer Publisher, 2011 (2nd Edition).
5.	Michael Grieves, “Product Life Cycle Management”, Tata McGraw Hill, 2006.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE017T	PROFESSIONAL ETHICS	3	0	0	0	3

PREREQUISITES: NIL

COURSE OBJECTIVES:

1.	To identify the core values that shape the ethical behavior of an engineer
2.	To utilize opportunities to explore one's own values in ethical issues
3.	To become aware of ethical concerns and conflicts
4.	To enhance familiarity with codes of conduct
5.	To increase the ability to recognize and resolve ethical dilemmas

UNIT	TITLE	PERIODS
1	**HUMAN VALUES**	**9**
Morals and Ethics - Honesty - Integrity - Values - Work Ethic - Civic Virtue - Respect for Others – Living Peacefully - Caring and Sharing - Self-Confidence - Courage - Co-operation - Commitment - Empathy		
UNIT	**TITLE**	**PERIODS**
2	**ENGINEERING ETHICS AND PROFESSIONALISM**	**9**
Scope of Engineering Ethics- Variety of moral issues - Types of inquiry - Accepting and sharing responsibility - Ethical dilemmas - Moral autonomy - Kohlbergs and Gilligan's theory - Consensus and controversy - Profession and Professionalism - Models of Professional Roles - Right action theories - Senses of corporate responsibility - Codes of ethics: Importance – justification - Limitation - Abuse.		
UNIT	**TITLE**	**PERIODS**
3	**ENGINEER'S AS SOCIAL EXPERIMENTATION & RESPONSIBILITY FOR SAFETY**	**9**
Engineering as Experimentation –Engineers as responsible Experimenters –Research Ethics -Codes of Ethics -Industrial Standards -A Balanced Outlook on Law - Cautious Optimism - Safety and Risk – Assessment of Safety and Risk –Risk Analysis –Reducing Risk –The Government Regulator's Approach to Risk -l Case Studies Chernobyl and Bhopal Gas Tragedy		
UNIT	**TITLE**	**PERIODS**
4	**RESPONSIBILITIES AND RIGHTS**	**9**
Fundamental Rights - Responsibilities and duties of Indian Citizen - Team work- Ethical corporate Climate - Collegiality and Loyalty –Respect for Authority –Collective Bargaining –Confidentiality –Conflicts of Interest – Occupational Crime –Professional Rights –Employee Rights –Intellectual Property Rights (IPR) - Discrimination		
UNIT	**TITLE**	**PERIODS**
5	**GLOBAL ISSUES**	**9**
Multinational Corporations –Business Ethics -Environmental Ethics –Computer Ethics -Role in Technological Development –Weapons Development –Engineers as Managers –Consulting Engineers –Engineers as		

Expert Witnesses and Advisors –Honesty –Moral Leadership –Sample Code of Conduct

	TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Apply Ethical Theories and Human Values in Engineering.
CO2:	Understand the Responsibility and Professionalism.
CO3:	Evaluate social experimentation with engineering approaches for Safety.
CO4:	Create Confidence in their approaches and claim their rights.
CO5:	Create moral leadership with the knowledge in global practices.

TEXT BOOKS:	
1.	Charles E Harris, Michael S Pritchard and Michael J Rabins, "Engineering EthicsConcepts and Cases", Cengage Learning., Belmont, 2009, ISBN-13: 978-0-495-50279-1 ISBN-10: 0-495-50279-0
2.	Mike Martin and Roland Schinzinger, "Introduction To Engineering Ethics", 2nd Edition McGraw Hill., New York, 2010, ISBN 978-0-07-248311-6—ISBN 0-07-248311-3

REFERENCE BOOKS:	
1.	Charles D Fleddermann, "Engineering Ethics", 4thedition, Prentice Hall., New Mexico, Newjersey, 1999, ISBN-13: 978-0-13-214521-3 , ISBN-10: 0-13-214521-9
2.	David Ermann and Michele S Shauf, "Computers, Ethics and Society", Oxford University Press,United Kingdom, 2002,ISBN: 9780195143027.
3.	Edmund G Seebauer and Robert L Barry, "Fundamentals of Ethics for Scientists and Engineers", 1st edition, Oxford University Press, United Kingdom, 2000, ISBN-13:978-0195134889, ISBN-10:0195134885
4.	John R Boatright, "Ethics and the Conduct of Business",8theditionPearson Education, Boston,2017,ISBN-10:9789352862306, ISBN-13:978-9352862306
5.	Prof. (Col) P S Bajaj and Dr. Raj Agrawal, "Business Ethics –An Indian Perspective", Wiley, 2004,ISBN-10:8177221671ISBN-13:9788177221671.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE021T	**QUALITY CONTROL AND RELIABILITY ENGINEERING**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: Statistical Quality Control

COURSE OBJECTIVES:	
1.	To introduce the concepts of SQC
2.	To understand the process control for Defects and Defectives
3.	To understand process control and acceptance sampling procedure and their application.
4.	To understand the concept of Life Testing & Reliability
5.	To learn the concept of product development and product life cycle

UNIT	TITLE	PERIODS
1	**INTRODUCTION AND PROCESS CONTROL FOR VARIABLES**	**9**
Introduction, definition of quality, basic concept of quality, definition of SQC, benefits and limitation of SQC, Quality assurance, Quality control: Quality cost-Variation in process causes of variation – Theory of control chart- uses of control chart –X chart, R chart and chart - process capability – process capability studies and simple problems. Six sigma concepts. Seven quality control tools		
UNIT	**TITLE**	**PERIODS**
2	**PROCESS CONTROL FOR ATTRIBUTES**	**9**
Control chart for attributes –control chart for non conforming– p chart and np chart – control chart for nonconformities– C and U charts, State of control and process out of control identification in charts, pattern study.		
UNIT	**TITLE**	**PERIODS**
3	**ACCEPTANCE SAMPLING**	**9**
Lot by lot sampling – types – probability of acceptance in single, sampling techniques – O.C. curves – producer's Risk and consumer's Risk. AQL, LTPD, AOQL concepts-standard sampling plans for AQL and LTPD- uses of standard sampling plans.		
UNIT	**TITLE**	**PERIODS**
4	**LIFE TESTING – RELIABILITY**	**9**
Life testing – Objective – failure data analysis, Mean failure rate, mean time to failure, mean time between failure, hazard rate – Weibull model, system reliability, series, parallel and mixed configuration – simple problems. Maintainability and availability – simple problems. Acceptance sampling based on reliability test – O.C Curves.		
UNIT	**TITLE**	**PERIODS**
5	**QUALITY AND RELIABILITY**	**9**
Reliability improvements – techniques- use of Pareto analysis – design for reliability – redundancy unit and standby redundancy – Optimization in reliability – Product design – Product analysis – Product development– Product life cycles.		
Case Study: Problem solving through R-programming/ Mini TAB		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, Student will be able to:	
CO1:	Employ various statistical methods to monitor quality of the process.
CO2:	Use of control charts for attributes to Analyze product quality.
CO3:	Determine the quality of a batch of products by using sampling techniques.
CO4:	Estimating the expected durability of a product over a period of time.
CO5:	Predict how well a product performs its proper functions.

TEXT BOOKS:	
1.	Douglus C. Montgomery, “Introduction to Statistical Quality Control”, Wiley-India, Seventh Edition, 2013.
2.	Srinath. L.S., “Reliability Engineering”, Affiliated East west press, 2008.

REFERENCE BOOKS:	
1.	AmitavaMitra, “Fundamentals of Quality Control and Improvement”, Wiley, Third Edition, 2008.
2.	Charles E.Ebeling, “An Introduction to Reliability and Maintainability Engineering”, TMH, 2007
3.	Connor, P.D.T.O., “Practical Reliability Engineering”, John Wiley, 2012
4.	Dale H. Besterfield, Quality Control, Pearson Education Asia, EightEdition, 2008
5.	Eugene L. Grant and Richard S. Leaven Worth, “Statistical Quality Control”, McGraw-Hill Education, Seventh Edition, 2000.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE022T	VIBRATION AND NOISE CONTROL	3	0	0	0	3

PREREQUISITES: 191MEC502T - MECHANICS OF MACHINES

COURSE OBJECTIVES:

1.	To familiarize with fundamentals of vibration noise
2.	To understand different noise propagation
3.	To gain knowledge on noise measurement and its instrumentation techniques
4.	To apply various noise control techniques
5.	To understand various vibration control strategies

UNIT	TITLE	PERIODS
1	INTRODUCTION TO VIBRATION NOISE	9
Definition, basic attributes of sound (wavelength, period, frequency velocity, speed, pressure, power and sound intensity), units (decibel, dB (A) and SPL), Wave analysis of structures and spaces.		
UNIT	**TITLE**	**PERIODS**
2	ENVIRONMENTAL NOISE PROPAGATION	9
Sources, distance from source, atmospheric absorption, wind, temperature, wind and temperature gradient, obstacles such as barriers and buildings, ground absorption, reflections, humidity.		
UNIT	**TITLE**	**PERIODS**
3	NOISE MEASUREMENT AND INSTRUMENTAION	9
Noise measurement and control instrumentation, Leq and various noise metrics for aircraft and industrial noises. Noise Level indicators, Noise severity criteria, Various types of acoustic testing chambers.		
UNIT	**TITLE**	**PERIODS**
4	NOISE CONTROL	9
Importance of reverberations time. Design of absorption systems for required reverberation time. Noise isolation design. Noise absorber design. Acoustic Design of Buildings Common strategies for reducing environmental noise exposure.		
UNIT	**TITLE**	**PERIODS**
5	VIBRATION CONTROL STRATEGIES	9
Review of Vibration control measures, design of a Vibration Absorbers, unconstrained and constrained layer damping treatment, add on dampers, and stiffeners. Design of Isolators in machine foundations, Role of materials damping. Introduction to Active Vibration Control.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:

Upon completion of this course, student will be able to:	
CO1:	Analyze different attributes of vibration and wave analysis of structure.
CO2:	Analyze the noise propagation mechanism in buildings.
CO3:	Apply acoustic testing methods to measure industrial vibration and noise
CO4:	Design noise absorption systems for reducing environmental noise exposure
CO5:	Develop test strategies of noise propagation

TEXT BOOKS:	
1.	Grover. G.T., “Mechanical Vibrations”, Nem Chand and Bros., 2009
2.	Singiresu S.Rao, “Mechanical Vibrations”, 6th Edition, Pearson Education, 2016.

REFERENCE BOOKS:	
1.	Balakumar Balachandran and Edward B. Magrab, “Fundamentals of Vibrations”,1st Editon, Cengage Learning, 2009
2.	Bernard Challen and Rodica Baranescu - “Diesel Engine Reference Book”, Second Edition, SAE International, 1999
3.	Colin Hansen , Scott Snyder , Laura Brooks, Active Control of Noise and Vibration, Second Edition, Volume 1, CRC Press, 2012
4.	Kewal Pujara, Vibration and Noise for Engineers, Dhanpat Rai & co, 2018

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE023T	**GAS DYNAMICS AND JET PROPULSION**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: 191MEC303T - Engineering Thermodynamics**,** 191MEC403T - Thermal Engineering

COURSE OBJECTIVES:	
1.	To understand the basics of compressible fluids and flow through variable ducts
2.	To understand the flow through constant area ducts
3.	To understand the phenomenon of shock waves and its effect on flow
4.	To gain basic knowledge about jet propulsion
5.	To gain basic knowledge about Rocket propulsion

UNIT	TITLE	PERIODS
1	**BASIC CONCEPTS AND ISENTROPIC FLOWS**	**9**
Energy and momentum equations of compressible fluid flows - Stagnation states, Mach waves and Mach cone - Effect of Mach number on compressibility - Isentropic flow through variable ducts - Nozzle and Diffusers.		
UNIT	**TITLE**	**PERIODS**
2	**FLOW THROUGH DUCTS**	**9**
Flow through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) - variation of flow properties.		
UNIT	**TITLE**	**PERIODS**
3	**NORMAL AND OBLIQUE SHOCKS**	**9**
Governing equations - Variation of flow parameters across the normal and oblique shocks - Prandtl - Meyer relations - Applications.		
UNIT	**TITLE**	**PERIODS**
4	**JET PROPULSION**	**9**
Theory of jet propulsion - Thrust equation - Thrust power and propulsive efficiency - Operating principle, cycle analysis and use of stagnation state performance of ram jet, turbojet, turbofan and turbo prop engines.		
UNIT	**TITLE**	**PERIODS**
5	**SPACE PROPULSION**	**9**
Types of rocket engines - Propellants - feeding systems - Ignition and combustion - Theory of rocket propulsion - Performance study - Staging - Terminal and characteristic velocity - Applications - space flights.		
Case studies: Study of specifications of Rockets - PSLV, GSLV		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Calculate stagnation and flow properties for isentropic compressible flow through constant area duct
CO2:	Calculate the stagnation and flow properties for constant area duct with heat transfer and friction
CO3:	Calculate the stagnation and flow properties in a normal, oblique shock waves
CO4:	Calculate the propulsion parameters in aircraft engine
CO5:	Calculate the propulsion parameters in rocket vehicles.

TEXT BOOKS:	
1.	Anderson, J.D., "Modern Compressible flow", 3rd Edition, McGraw Hill, 2012.
2.	Cohen. H., G.E.C. Rogers and Saravanamutto, "Gas Turbine Theory", 5th Edition, Longman Group Ltd., 2013
3.	Yahya, S.M., "Fundamentals of Compressible Flow", 6th Edition, New Age International (P) Limited, New Delhi, 2018.

TABLES:	
1.	Yahya, S.M., “Gas Tables”, New Age International Publishers, 2018.

REFERENCE BOOKS:	
1.	Ganesan. V., "Gas Turbines", Tata McGraw Hill Publishing Co., New Delhi, 2010.
2.	Shapiro. A.H., "Dynamics and Thermodynamics of Compressible fluid flow", John wiley, New York, 1953.
3.	Sutton. G.P., "Rocket Propulsion Elements", John Wiley, New York, 2010.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE024T	**FLUIDS ENGINEERING**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To understand the basic concepts of fluids
2.	To learn the working principle of pumps and actuators
3.	To learn about the various types of valves and working
4.	To know about the pneumatic applications
5.	To understand the applications and working of hydraulic turbines

UNIT	TITLE	PERIODS
1	**INTRODUCTION TO FLUID PROPERTIES AND POWER SYSTEMS**	**9**

Types, properties, and selection, characteristics of fluid flow, effect of temperature and pressure on hydraulic fluid, components, advantages and applications. Transmission of power at static and dynamic states. Pascal's law and its applications. Seals and materials, compatibility of seal with fluids. Types of pipes, hoses, and quick acting couplings. Pressure drop in hoses / pipes.

UNIT	TITLE	PERIODS
2	**PUMPS AND ACTUATORS**	**9**

Pumps: Classification of pumps, construction and working, performance characteristics, pump selection factors, problems on pumps. Actuators: Classification cylinder and hydraulic motors, Hydraulic cylinders, single and double acting cylinder, mounting arrangements, cushioning, special types of cylinders, problems on cylinders.

UNIT	TITLE	PERIODS
3	**COMPONENTS AND HYDRAULIC CIRCUIT DESIGN**	**9**

Components: Classification of control valves, Directional Control Valves and symbols, constructional features of rotary type valves solenoid and pilot operated DCV, shuttle valve, and check valves. Pressure control valves - types, direct operated types and pilot operated types.

Hydraulic Circuit Design: Control of single and Double -acting hydraulic cylinder, regenerative circuit, pump unloading circuit, double pump hydraulic system, counter balance valve application, hydraulic cylinder sequencing circuits, cylinder synchronizing circuit using different methods, hydraulic circuit for force multiplication.

UNIT	TITLE	PERIODS
4	PNEUMATIC POWER SYSTEMS	9

Introduction to Pneumatic Systems: Pneumatic power system, advantages, limitations, applications, choice of working medium. Characteristics of compressed air compressors. Structure of pneumatic control system, FRL unit. Pneumatic Actuators and control valves: Linear cylinder – types, working, end position cushioning, mounting arrangements and applications. Rotary cylinders – types, construction and application, symbols. DCV such as poppet, spool, suspended seat type slide valve, pressure control valves.

UNIT	TITLE	PERIODS
5	HYDRAULIC TURBINES	9

Introduction, Classification of turbines, Impulse and reaction turbines, construction, working and performance of Pelton, Francis and Kaplan Turbines, Draft tube, Governing of hydraulic turbines, Cavitation.

TOTAL PERIODS:	**45**

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1:	Learn the basic concepts of fluids and power systems
CO2:	Select suitable pumps and actuators for the specific applications
CO3:	Design hydraulic circuits for the desired applications
CO4:	Design pneumatic circuits for the desired applications
CO5:	Calculate the performance of hydraulic turbines

TEXT BOOKS:

1.	Fluid Mechanics and Fluid Power Engineering by D.S. Kumar, S.K. Kataria & Sons.2014
2.	Fluid Power Engineering by R.N. Patel and V.L. Patel Mahajan Publication.2012

REFERENCE BOOKS:

1.	Fluid Mechanics and Hydraulic Machines by R.K. Bansal, Laxmi Prakashan.2016
2.	Fluid Mechanics and Hydraulic Machines by R.K. Rajput, S.Chand & Co.2011

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE025T	**ENERGY CONSERVATION AND MANAGEMENT**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: Thermal Engineering

COURSE OBJECTIVES:	
1	Understand and analyze the energy data of industries
2	Carryout energy accounting and balancing
3	Conduct energy audit and suggest methodologies for energy savings and
4	Utilize the available resources in optimal ways
5.	To learn Energy Conservation practices using Economics principles and Strategies.

UNIT	TITLE	PERIODS
1	**INTRODUCTION**	**8**
Energy - Power – Past & Present scenario of World; National Energy consumption Data – Environmental aspects associated with energy utilization –Energy Auditing: Need, Types, Methodology and Barriers. Role of Energy Managers. Instruments for energy auditing.		
UNIT	**TITLE**	**PERIODS**
2	**ELECTRICAL SYSTEMS**	**12**
Components of EB billing – HT and LT supply, Transformers, Cable Sizing, Concept of Capacitors, Power Factor Improvement, Harmonics, Electric Motors - Motor Efficiency Computation, Energy Efficient Motors, Illumination – Lux, Lumens, Types of lighting, Efficacy, LED Lighting and scope of Encon in Illumination.		
UNIT	**TITLE**	**PERIODS**
3	**THERMAL SYSTEMS**	**12**
Stoichiometry, Boilers, Furnaces and Thermic Fluid Heaters – Efficiency computation and encon measures. Energy Efficiency of turbines, compressors and pumps, specific energy consumption, parameters affecting specific energy consumption, flexi targeting technique. Cogeneration: types and schemes, case study , Steam: Distribution &U sage: Steam Traps, Condensate Recovery, Flash Steam Utilization, Insulators & Refractories,The Energy efficiency home.		
UNIT	**TITLE**	**PERIODS**
4	**ENERGY CONSERVATION IN MAJOR UTILITIES**	**8**
Pumps, Fans, Blowers, Compressed Air Systems, Refrigeration and Air Conditioning Systems – Cooling Towers – D.G. sets. Energy Audits and Improvements for Commercial Buildings		
UNIT	**TITLE**	**PERIODS**
5	**ECONOMICS**	**5**
Energy Economics – Discount Rate, Payback Period, Internal Rate of Return, Net Present Value, Life		

Cycle Costing –ESCO concept, Energy conservation in vehicles, energy conservation in buildings, Power quality issues related to Energy Efficient Technologies, Energy Conservation Practice – Case Studies
Case studies: Energy saving measures/ projects, Heat Ventilating and Air-Conditioning (HVAC) -Energy Conservation Practice

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Demonstrate the energy auditing methods, barriers with the help of energy auditing instruments
CO2:	Evaluate the energy efficiencies of electrical systems through energy audit
CO3:	Evaluate the energy efficiencies of thermal systems through energy audit
CO4:	Infer the areas where energy conservation is possible for improvements in commercial buildings
CO5:	Evaluate the energy economic strategies of vehicles and buildings
CO6:	Estimate the energy utilization and conservation in buildings and vehicles

TEXT BOOKS:	
1.	Ian M. Shapiro, “Energy Audits and Improvements for Commercial Buildings”Wiley,2011
2.	K. V. Sharma., P. Venkataseshaiah, “Energy Management and Conservation”I K International Publishing, 2011.
3.	S. S. Thipse. “Energy Conservation and Management”,Alpha Science International, 2014.

REFERENCE BOOKS:	
1.	Callaghn, P.W. “Design and Management for Energy Conservation”, Pergamon Press, Oxford, 1981.
2.	Patrick Waterfield.” The ENERGY EFFICIENT HOME: A Complete Guide “2011.
3.	Witte. L.C., P.S. Schmidt, D.R. Brown, “Industrial Energy Management and Utilisation” Hemisphere Publ, Washington, 1988.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE026T	**MACHINE LEARNING FOR INTELLIGENT SYSTEMS**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To introduce basic machine learning techniques such as regression, classification
2.	To learn about introduction of clustering, types and segmentation methods
3.	To learn about fuzzy logic, fuzzification and defuzzification
4.	To learn about basics of neural networks and neuro fuzzy networks.
5.	To learn about Recurrent neural networks and Reinforcement learning.

UNIT	TITLE	PERIODS
1	**INTRODUCTION TO MACHINE LEARNING**	**9**
Philosophy of learning in computers, Overview of different forms of learning, Classifications vs. Regression, Evaluation metrics and loss functions in Classification, Evaluation metrics and loss functions in Regression, Applications of AI in Robotics.		
UNIT	**TITLE**	**PERIODS**
2	**CLUSTERING AND SEGMENTATION METHODS**	**9**
Introduction to clustering, Types of Clustering, Agglomerative clustering, K-means clustering, Mean Shift clustering, K-means clustering application study, Introduction to recognition, K-nearest neighbor algorithm, KNN Application case study, Principal component analysis (PCA), PCA Application case study in Feature Selection for Robot Guidance.		
UNIT	**TITLE**	**PERIODS**
3	**FUZZY LOGIC**	**9**
Introduction to Fuzzy Sets, Classical and Fuzzy Sets, Overview of Classical Sets, Membership Function, Fuzzy rule generation, Fuzzy rule generation, Operations on Fuzzy Sets, Numerical examples, Fuzzy Arithmetic, Numerical examples, Fuzzy Logic, Fuzzification, Fuzzy Sets, Defuzzification, Application Case Study of Fuzzy Logic for Robotics Application		
UNIT	**TITLE**	**PERIODS**
4	**NEURAL NETWORKS**	**9**
Mathematical Models of Neurons, ANN architecture, Learning rules, Multi-layer Perceptrons, Back propagation, Introduction of Neuro-Fuzzy Systems, Architecture of Neuro Fuzzy Networks, Application Case Study of Neural Networks in Robotics		
UNIT	**TITLE**	**PERIODS**
5	**RNN AND REINFORCEMENT LEARNING**	**9**
Unfolding Computational Graphs, Recurrent neural networks, Application Case Study of recurrent networks		

in Robotics, Reinforcement learning, Examples for reinforcement learning, Markov decision process, Major components of RL, Q-learning. Application Case Study of reinforcement learning in Robotics

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Understand basic machine learning techniques such as regression, classification
CO2:	Understand about clustering and segmentation
CO3:	Model a fuzzy logic system with fuzzification and defuzzification
CO4:	Understand the concepts of neural networks and neuro fuzzy networks.
CO5:	Gain knowledge on Reinforcement learning.

TEXT BOOKS:	
1.	Micheal Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems, 3rd Edition, Addision Wesley, England, 2011

REFERENCE BOOKS:	
1.	Bruno Siciliano, Oussama Khatib, “Handbook of Robotics”, 2016 2nd Edition, Springer
2.	Simon Haykin, “Neural Networks and Learning Machines: A Comprehensive Foundation”, Third Edition, Pearson, delhi 2016.
3.	Timothy J Ross, “Fuzzy Logic with Engineering Applications”, 4th Edition, Chichester, 2011, Sussex Wiley.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE027T	**ENGINEERING ECONOMICS AND FINANCIAL ACCOUNTS**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: Nil

COURSE OBJECTIVES:	
1.	To introduce the concept of Economics and cost Analysis to engineering and take economically sound decision
2.	To Introduce the concept of Good working condition at the lowest cost
3.	To Introduce the concept of Work Management
4.	To Introduce the concept of operational performance and Economics position of an enterprise
5.	To introduce Economic Theory in Engineering Practices

UNIT	TITLE	PERIODS
1	**FINANCIAL ACCOUNTING**	**12**
Accounting principles –preparation and interpretation of profit and loss statement –balance sheet –Fixed assets –current assets –depreciation –depreciation methods		
UNIT	**TITLE**	**PERIODS**
2	**PROFIT VOLUME ANALYSIS**	**10**
Cost volume profit relationship –relevant costs in decision making –profit management analysis –break even analysis –margin of safety –angle of incidence and multi product break even analysis Effect of changes in volume, selling price, fixed cost and variable cost.		
UNIT	**TITLE**	**PERIODS**
3	**WORKING CAPITAL MANAGEMENT**	**8**
Current assets and liability decisions –Estimation of working capital requirements –Management of accounts receivable –Inventory –Cash –Inventory valuation methods.		
UNIT	**TITLE**	**PERIODS**
4	**CAPITAL BUDGETING**	**7**
Significance of capital budgeting –payback period –present value method –Accounting rate of return method		
UNIT	**TITLE**	**PERIODS**
5	**ENGINEERING ECONOMICS**	**8**
Economics –Engineering economics –Demand analysis –Laws of demand –Production and cost –Pricing methods –Cost volume profit analysis.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:

Upon completion of this course, student will be able to:	
CO1:	Prepare and interpret financial statements.
CO2:	Perform Profit analysis.
CO3:	Estimating the working capital management.
CO4:	Manage the capital budgeting.
CO5:	Understand the principles of Engineering Economics.

TEXT BOOKS:	
1.	R.Kesavan, C. Elanchezian and T.Sundar Selwyn –Engineering Economics and Financial Accounting, Laxmi Publications 2005.
2.	Panneer Selvam, R, "Engineering Economics", Prentice Hall of India Ltd, New Delhi, 2001.

REFERENCE BOOKS:	
1.	C.James, Vanhorn, Fundamentals of Financial Management PHI 1996.
2.	Charles T.Homgren, Cost Accounting, PHI 1985
3.	S.N.Maheswaran, Management Accounting and Financial Control, Sultan Chand, 1992.

Course Code	Course Title	Periods per week				Credits
		L	T	P	C	
191MEE031T	**MAINTENANCE ENGINEERING**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To enable the student to understand the principles, functions and practices adapted in industry for the successful management of maintenance activities.
2.	To explain the different maintenance categories like Preventive maintenance, condition monitoring and repair of machine elements.
3.	To illustrate some of the simple instruments used for condition monitoring in industry.
4.	To gain knowledge in repair methods for basic machine elements.
5.	To gain knowledge in repair methods for special machines line material handling equipment.

UNIT	TITLE	PERIODS
1	**PRINCIPLES AND PRACTICES OF MAINTENANCE PLANNING**	**9**
Basic Principles of maintenance planning – Objectives and principles of planned maintenance activity – Importance and benefits of sound Maintenance systems – Reliability and machine availability – MTBF, MTTR and MWT – Factors of availability – Maintenance organization – Maintenance economics.		
UNIT	**TITLE**	**PERIODS**
2	**MAINTENANCE POLICIES – PREVENTIVE MAINTENANCE**	**9**
Maintenance categories – Comparative merits of each category – Preventive maintenance, maintenance schedules, repairs cycle - Principles and methods of lubrication – TPM.		
UNIT	**TITLE**	**PERIODS**
3	**CONDITION MONITORING**	**9**
Condition Monitoring – Cost comparison with and without CM – On-load testing and offload testing – Methods and instruments for CM – Temperature sensitive tapes – Pistol thermometers – wear-debris analysis		
UNIT	**TITLE**	**PERIODS**
4	**REPAIR METHODS FOR BASIC MACHINE ELEMENTS**	**9**
Repair methods for beds, slide ways, spindles, gears, lead screws and bearings – Failure analysis – Failures and their development – Logical fault location methods – Sequential fault location.		
UNIT	**TITLE**	**PERIODS**
5	**REPAIR METHODS FOR MATERIAL HANDLING EQUIPMENT**	**9**
Repair methods for Material handling equipment - Equipment records –Job order systems -Use of computers in maintenance.		
Case studies: Maintenance of hydraulic pumps used in an excavator. Maintenance check and problem identification in Special machines laboratory.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Implement the maintenance function and different practices in industries for the successful management of maintenance activities
CO2:	Compare different maintenance categories like Preventive maintenance & Lubrication Methods.
CO3:	Use condition monitoring for effective maintenance of machines.
CO4:	Examine appropriate repair methods and fault analysis of basic machine elements.
CO5:	Adopt appropriate repair methodology for material handling equipments.

TEXT BOOKS:	
1.	Srivastava S.K., “Industrial Maintenance Management”, S. Chand and Co., 1981
2.	Venkataraman .K “Maintancence Engineering and Management”, PHI Learning, Pvt. Ltd., 2007

REFERENCE BOOKS:	
1.	Bhattacharya S.N., “Installation, Servicing and Maintenance”, S. Chand and Co., 1995
2.	Garg M.R., “Industrial Maintenance”, S. Chand & Co., 1986.
3.	White E.N., “Maintenance Planning”, I Documentation, Gower Press, 1979.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE032T	**MECHANICS OF COMPOSITE MATERIALS**	3	0	0	0	3

PREREQUISITES: Strength of materials

COURSE OBJECTIVES:

1.	To gain knowledge on Composite structures
2.	To familiarized with composite structural design and joints
3.	To understand design basics
4.	To learn elastic properties of lamina
5.	To obtain knowledge on analysis of laminated composites

UNIT	TITLE	PERIODS
1	**INTRODUCTION TO COMPOSITE STRUCTURES**	**9**
Types of composites, Engineering applications, Manufacturing process, materials selection and design requirements		
UNIT	**TITLE**	**PERIODS**
2	**COMPOSITES LAMINATES**	**9**
Lamina, Laminate: The basic building block of a composite material, Laminate joints, optimization concepts		
UNIT	**TITLE**	**PERIODS**
3	**ANALYSIS OF COMPOSITE STRENGTH AND STIFFNESS**	**9**
Properties of typical composite materials. Volume and Weight Fractions. Longitudinal Strength and Stiffness. Transverse Modulus. In-plane shear Modulus. Poisson's ratio		
UNIT	**TITLE**	**PERIODS**
4	**ELASTIC PROPERTIES OF THE UNIDIRECTIONAL LAMINA**	**9**
Stress-strain relationships. Engineering Constants. Stress strain relations of a Thin Lamina. Examples		
UNIT	**TITLE**	**PERIODS**
5	**ANALYSIS OF LAMINATED COMPOSITES**	**9**
Laminates, Basic Assumptions, Strain-Displacement Relationship, inter laminar stresses, weak bonding, de bonding, Stress-Strain Relationships, Equilibrium Equations, Laminate Stiffness, Determination of Lamina Stresses and Strains, Types of Laminate Configuration, Balanced Laminate, Anti-symmetric Laminate, Introduction to asymmetric stress tensor analysis, examples		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1:	Explain the engineering applications of composite materials
CO2:	Apply fundamental concepts to fabricate composite structures
CO3:	Analyze the strength and stiffness of composite laminates
CO4:	Determine the Elastic Properties of unidirectional Laminated composites
CO5:	Apply classical laminate theory to predict strength of a given composite laminate

TEXT BOOKS:

1.	Isaac M. Daniel, Ori Ishai, Engineering Mechanics of Composite Materials, Second edition Oxford University Press, 2006, First Indian Edition – 2007
2.	Robert M johns, Mechanics of Composite Materials, CRC Press, 2003

REFERENCE BOOKS:

1.	Chawla Krishnan K, Composite Materials Science & engineering, Springer, Third edition 2012.
2.	Christophe Bout ,Mechanics of Aeronautical composite materials ,Wiley 2013
3.	Madhujit Mukhop, Mechanics of FRP Composite Materials & Structure, Universities Press 2004.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE033T	**THERMAL POWER SYSTEMS**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:

1.	To study the fuel properties and arrive at proximate and ultimate analysis of fuels.
2.	To study the different types of boilers and compute their performance parameters.
3.	To study the performance parameters of an air compressor
4.	To study the working principles of various refrigeration systems and perform cop calculations
5.	To study the psychrometric properties and how they are utilized in arriving at calculations to determine heating loads

UNIT	TITLE	PERIODS
1	**FUELS AND COMBUSTION**	**9**

Fuels - Types and Characteristics of Fuels - Determination of Properties of Fuels – Fuels Analysis - Proximate and Ultimate Analysis - Moisture Determination - Calorific Value -Gross & Net Calorific Values

UNIT	TITLE	PERIODS
2	**BOILERS**	**9**

Types and comparison, Mountings and Accessories. Performance calculations, Boiler trial.

UNIT	TITLE	PERIODS
3	**AIR COMPRESSORS**	**9**

Classification and comparison, working principle, work of compression - with and without clearance, Volumetric efficiency, Isothermal efficiency and Isentropic efficiency. Multistage air compressor with Intercooling. Working principle and comparison of Rotary compressors with reciprocating air compressors

UNIT	TITLE	PERIODS
4	**REFRIGERATION SYSTEMS**	**9**

Vapour compression refrigeration cycle, Effect of Superheat and Sub-cooling, Performance calculations, Working principle of air cycle, vapour absorption system, and Thermoelectric refrigeration.

UNIT	TITLE	PERIODS
5	**PSYCHROMETRY AND AIR-CONDITIONING**	**9**

Psychrometric properties – Property calculations using Psychrometric chart and expressions. Psychrometric processes – adiabatic saturation, sensible heating and cooling, humidification, dehumidification, evaporative cooling and adiabatic mixing Air conditioning systems, concept of RSHF, GSHF and ESHF, Cooling load calculations. Cooling towers – concept and types.

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Evaluate the fuel properties and arrive at proximate and ultimate analysis of fuels.
CO2:	Analyze different types of boilers and compute their performance parameters.
CO3:	Evaluate the performance parameters of an air compressor
CO4:	Apply the working principles of various refrigeration systems and perform cop calculations.
CO5:	Analyze the psychrometric properties and how they are utilized in arriving at calculations to determine heating loads.

TEXT BOOKS:	
1.	Ballaney. P, “ Thermal Engineering”, 25th Edition, Khanna Publishers, 2017
2.	Mahesh. M. Rathore, “Thermal Engineering”, 1st Edition, Tata McGraw Hill, 2010.

REFERENCE BOOKS:	
1.	Ananthanarayanan P.N, “ Basic Refrigeration and Air-Conditioning”, 4th Edition, Tata McGraw Hill, 2013.
2.	Arora, “ Refrigeration and Air-Conditioning”, 2nd Edition, Prentice Hall of India, 2010.
3.	Mathur M.L and Mehta F.S., “Thermal Science and Engineering”, 3rd Edition, Jain Brothers Pvt. Ltd, 2017.
4.	Nag P.K, “ Basic and Applied Thermodynamics”, 2nd Edition, Tata McGraw Hill, 2010
5.	Soman. K, “Thermal Engineering”, 2nd Edition, Prentice Hall of India, 2011

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE034T	**COMPUTATIONAL FLUID DYNAMICS**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: Fluid Mechanics, Finite Element Analysis and Heat and Mass Transfer

COURSE OBJECTIVES:	
1	To introduce Governing Equations of viscous fluid flows
2	To introduce numerical modeling and its role in the field of fluid flow and heat transfer
3	To enable the students to understand discretization methods, solution procedures and turbulence modeling.
4	To create confidence to solve complex problems in the field of fluid flow and heat transfer by using high speed computers.
5.	To understand advances in numerical methods and techniques and advances in computational models.

UNIT	**TITLE**	**PERIODS**
1	**GOVERNING EQUATIONS AND BOUNDARY CONDITIONS**	**8**
Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity, Momentum and Energy equations – Chemical species transport – Physical boundary conditions – Time-averaged equations for Turbulent Flow – Turbulent–Kinetic Energy Equations – Mathematical behavior of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations.		
UNIT	**TITLE**	**PERIODS**
2	**FINITE VOLUME METHODS FOR DIFFUSION**	**9**
Introduction to finite difference equations – FVM – General Methods for first and second order accuracy – Finite volume formulation for steady state One, Two and Three -dimensional diffusion problems –Parabolic equations – Explicit and Implicit schemes – Example problems on elliptic and parabolic equations – Use of Finite Volume methods.		
UNIT	**TITLE**	**PERIODS**
3	**FINITE VOLUME METHOD FOR CONVECTION DIFFUSION**	**10**
Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law, QUICK Schemes.		
UNIT	**TITLE**	**PERIODS**
4	**FLOW FIELD ANALYSIS**	**9**
Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.CFD solution analysis-Essentials.		
UNIT	**TITLE**	**PERIODS**

5	TURBULENCE MODELS AND MESH GENERATION	9
Turbulence models, mixing length model, Two equation (k-?) models – High and low Reynolds number models – Structured Grid generation – Unstructured Grid generation – Mesh refinement – Adaptive mesh – Software tools. Advances in numerical methods and techniques, Advances in computational models.		

	TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able :	
CO1:	Formulate the problems of fluid flow and heat transfer by selecting the correct governing equation and boundary conditions
CO2:	Discretize and solve the steady state and transient diffusion equation by finite volume method
CO3:	Discretize and solve the steady state convection- diffusion equation by finite volume method
CO4:	Discretize incompressible 2D flow equation by finite volume method.
CO5:	Include the effect of turbulence in the flow algorithm by selecting the correct turbulence model for the flow problem
CO6:	Select structured and unstructured meshes for a given fluid flow problem

TEXT BOOKS:	
1.	Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The finite volume Method", Pearson Education Ltd., Second Edition, 2007.
2.	Müller, J.D. “Essentials of computational fluid dynamics”. CRC Press, 2015.
3.	Tu, J., Yeoh, G.H. and Liu, C., “Computational fluid dynamics: a practical approach” , Butterworth-Heinemann,2018.

REFERENCE BOOKS:	
1.	Chung, T.J. "Computational Fluid Dynamics", Cambridge University, Press, 2002.
2.	Ghoshdastidar P.S., "Heat Transfer", Oxford University Press, 2005
3.	Anil W. Date "Introduction to Computational Fluid Dynamics" Cambridge University Press, 2005.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE035T	**ENVIRONMENTAL SUSTAINABILITY AND IMPACT ANALYSIS**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To make the students to understand the concepts of Environmental Sustainability & Impact Assessment
2.	To familiarize the students in environmental decision-making procedure.
3.	Make the students to identify, predict and evaluate the economic, environmental, and social impact of development activities
4.	To provide information on the environmental consequences for decision making
5.	To promote environmentally sound and sustainable development through the identification of appropriate alternatives and mitigation measures.

UNIT	TITLE	PERIODS
1	**ENVIRONMENTAL IMPACT ASSESMENT**	**9**
Environmental impact assessment objectives – rationale and historical development of EIA - Conceptual frameworks for EIA Legislative development – European community directive – Hungarian directive.		
UNIT	**TITLE**	**PERIODS**
2	**ENVIRONMENTAL DECISION MAKING**	**9**
Strategic environmental assessment and sustainability appraisal – Mitigation, monitoring and management of environmental impacts- Socio economic impact assessment.		
UNIT	**TITLE**	**PERIODS**
3	**ENVIRONMENTAL POLICY, PLANNING AND LEGISLATION**	**9**
Regional spatial planning and policy – Cumulative effects assessment – Planning for climate change, uncertainty and risk.		
UNIT	**TITLE**	**PERIODS**
4	**LIFE CYCLE ASSESSMENT**	**9**
Life cycle assessment; Triple bottom line approach; Industrial Ecology. Ecological foot printing, Design for Environment, Future role of LCA, Product stewardship, design, durability and justifiability, measurement techniques and reporting.		
UNIT	**TITLE**	**PERIODS**
5	**SUSTAINABLE URBAN ECONOMIC DEVELOPMENT**	**9**
Spatial economics – Knowledge economy and urban regions.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Explain the concepts of Environment Sustainability and trained to make decision related to Environment.
CO2:	Make decision that has an effect on our environment
CO3:	Evaluate the basics of environmental policy, planning and various legislation Get valuable information for exploring decisions in each life stage of materials, buildings, services and infrastructure.
CO4:	Develop the Life cycle assessment of Environmental sustainability.
CO5:	Analyze the sustainable urban economic development in different regions.

TEXT BOOKS:	
1.	The Application of Science in Environmental Impact Assessment, by Aaron J. MacKinnon, Peter N. Duinker , Tony R. Walker , Routledge; 1st edition (14 May 2019), ISBN-10 : 0367340194
2.	Routledge Handbook of Environmental Impact Assessment, by Kevin Hanna, Routledge; 1st edition (11 April 2022), ISBN-10 : 0367244470

REFERENCE BOOKS:	
1.	Clive George, C. Collin, H. Kirkpolarice – Impact Assessment and sustainable development – Edward Elgar Publishing, 2007
2.	Robort B Gibsan, Sustainability Assessment, Earth Scan publishers, 2005
3.	Simon Dresner, The principle of sustainability – Earth Scan publishers, 2008
4.	Canter, R.L., “Environmental Impact Assessment”, McGraw Hill Inc., New Delhi, 1996.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE036T	**INDUSTRIAL ROBOTICS**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To gain knowledge in the basic principles and information on robotics, robot configurations and robot motions.
2.	To learn major robot control components and operations required to automate a process or an activity
3.	To familiar with appropriate sensor and machine vision system for a given application.
4.	To learn the programming techniques for various robotic applications.
5.	To understand the robots in various industrial sectors and summarize the need and application of robots in different sectors.

UNIT	TITLE	PERIODS
1	**INTRODUCTION**	**9**
Definition of a Robot - Basic Concepts –Application- Robot configurations - Types of Robot drives - Basic robot motions - Point to point control - Continuous path control.		
UNIT	**TITLE**	**PERIODS**
2	**COMPONENTS AND OPERATIONS**	**10**
Basic control system concepts - control system analysis - robot actuation and feedback, Manipulators - director and inverse kinematics, Coordinate transformation - Brief Robot dynamics - Types of Robot end effectors - Grippers - Tools as end effectors		
UNIT	**TITLE**	**PERIODS**
3	**SENSING AND MACHINE VISION**	**7**
Range sensing - Proximity sensing - Touch sensing - Force and Torque sensing. Introduction to Machine vision - Sensing and digitizing - Image processing and analysis.		
UNIT	**TITLE**	**PERIODS**
4	**ROBOT PROGRAMMING**	**9**
Methods - languages - Capabilities and limitation - Artificial intelligence - Knowledge representation - Search techniques - AI and Robotics.		
UNIT	**TITLE**	**PERIODS**
5	**INDUSTRIAL APPLICATIONS AND ECONOMICS**	**9**
Application of robots in machining - Welding - Assembly - Material handling - Loading and unloading - CIM - Hostile and remote environments – Safety Considerations for Robot Operations- Economic Analysis of Robots.		
Case Studies: Collaborative robot system, Agricultural robotics.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Articulate the basic concepts of Robots, Robot drives and controls.
CO2:	Apply inverse kinematics and robot dynamics for basic control system and its components.
CO3:	Interpret images acquired through various sensors using machine vision techniques.
CO4:	Create programs for Robots using the AI concepts of Knowledge representation and Search techniques
CO5:	Apply Robots for various industrial applications.

TEXT BOOKS:	
1.	Groover M.P., “Industrial Robotics -Technology, Programming and Applications”, McGraw Hill Education, 2017.
2.	Klafter R.D., Chmielewski T.A and Negin M., “Robotic Engineering - An Integrated Approach”,Prentice Hall, 2003.

REFERENCE BOOKS:	
1.	Craig J.J., “Introduction to Robotics Mechanics and Control”, Pearson Education, 2008.
2.	Deb S.R., “Robotics Technology and Flexible Automation” Tata McGraw Hill Book Co., 2013.
3.	Fu.K.S.,Gonzalz R.C. and Lee C.S.G., “Robotics Control, Sensing, Vision and Intelligence”, McGraw Hill Book Co., 1987.
4.	Janakiraman P.A., “Robotics and Image Processing”, Tata McGraw Hill, 1995.
5.	Koren Y., “Robotics for Engineers", Mc Graw Hill Book Co., 1992.
6.	Ray Asfahl. C., “Robots and Manufacturing Automation”, John Wiley & Sons Inc.,1985

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE037T	**OPERATIONS RESEARCH**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To understand the various model formations and their industrial applications.
2.	To understand the various models of transportation and assignment problems.
3.	To evaluate the critical path and duration of project & process.
4.	To understand about replacement methods with sequencing.
5.	To understand the concept of Inventory control and queuing theory.

UNIT	TITLE	PERIODS
1	**LINEAR MODEL**	**9**
The phases of OR study – Formation of an L.P model – Graphical solution – Simplex algorithm – Artificial variables technique (Big M method, two phase method), Duality in simplex.		
UNIT	**TITLE**	**PERIODS**
2	**TRANSPORTATION AND ASSIGNMENT PROBLEM**	**9**
Transportation model – Initial solution by North West corner method – Least Cost method – VAM. Optimality test – MODI method and stepping stone method. Assignment model – Formulation – Balanced and unbalanced assignment problems.		
UNIT	**TITLE**	**PERIODS**
3	**PROJECT MANAGEMENT BY PERT & CPM**	**9**
Basic terminologies – Constructing a project network – Scheduling computations – PERT - CPM – Resource smoothening, Resource leveling, PERT Cost.		
UNIT	**TITLE**	**PERIODS**
4	**REPLACEMENT AND SEQUENCING MODELS**	**9**
Replacement policies - Replacement of items that deteriorate with time (value of money not changing with time) – Replacement of items that deteriorate with time (Value of money changing with time) – Replacement of items that fail suddenly (individual and group replacement policies). Sequencing models- n job on 2 machines – n jobs on 3 machines – n jobs on m machines, Traveling salesman problem.		
UNIT	**TITLE**	**PERIODS**
5	**INVENTORY AND QUEUING THEORY**	**9**
Variables in inventory problems, EOQ, deterministic inventory models, order quantity with price break, techniques in inventory management. Selective inventory control, Safety stock calculations, Queuing system and its structure – Kendall's notation – Common queuing models - M/M/1:FCFS/8/8 - M/M/1: FCFS/n/8 - M/M/C: FCFS/8/8 .		
	TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Apply linear programming model for optimizing various industrial process.
CO2:	Analyze the various methods under transportation model for evolving the optimal results.
CO3:	Apply the concepts of PERT and CPM for decision making in managing projects.
CO4:	Analyze the various replacement and sequencing models for arriving at optimal decision.
CO5:	Apply appropriate inventory and queuing theories in domain specific situations.

TEXT BOOKS:	
1.	Hira and Gupta “Problems in Operations Research”, S.Chand and Co.2008
2.	Taha H.A, “Operation Research”, Pearson Education sixth edition, 2003

REFERENCE BOOKS:	
1.	Budnick F.S., “Principles of Operations Research for Management”, Richard D Irwin, 1990.
2.	Shennoy G.V. and Srivastava U.K., “Operation Research for Management”, Wiley Eastern, 1994.
3.	Tulsian and Pasdey V., “Quantitative Techniques”, Pearson Asia, 2002.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE041T	COMPUTER INTEGRATED MANUFACTURING	3	0	0	0	3

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To understand the application of computers in various aspects of Manufacturing viz., Design, Proper planning, Manufacturing cost, Layout & Material Handling system.
2.	To provide knowledge on Group Technology and Computer Aided Process Planning
3.	To impart knowledge on Shop Floor Control and Flexible Manufacturing Systems
4.	To learn the various CIM implementation and data communication techniques.
5.	To provide knowledge on the concept of Manufacturing automation protocol, Technical office protocol and database terminology.

UNIT	TITLE	PERIODS
1	**INTRODUCTION**	**9**
Brief introduction to CAD and CAM – Manufacturing Planning, Manufacturing control- Introduction to CAD/CAM – Concurrent Engineering-CIM concepts – Computerised elements of CIM system – Types of production - Manufacturing models and Metrics – Mathematical models of Production Performance – Simple problems – Manufacturing Control – Simple Problems – Basic Elements of an Automated system – Levels of Automation – Lean Production and Just-In-Time Production.		
UNIT	**TITLE**	**PERIODS**
2	**PRODUCION PLANNING AND CONTROL & COMPUTERISED PROCESS PLANING**	**9**
Process planning – Computer Aided Process Planning (CAPP) – Logical steps in Computer Aided Process Planning – Aggregate Production Planning and the Master Production Schedule – Material Requirement planning – Capacity Planning- Control Systems-Shop Floor Control-Inventory Control – Brief on Manufacturing Resource Planning-II (MRP-II) & Enterprise Resource Planning (ERP) - Simple Problems.		
UNIT	**TITLE**	**PERIODS**
3	**CELLULAR MANUFACTURING**	**9**
Group Technology (GT), Part Families – Parts Classification and coding – Simple Problems in Opitz Part Coding system – Production flow Analysis – Cellular Manufacturing – Composite part concept – Machine cell design and layout – Quantitative analysis in Cellular Manufacturing – Rank Order Clustering Method - Arranging Machines in a GT cell – Hollier Method – Simple Problems.		
UNIT	**TITLE**	**PERIODS**
4	**FLEXIBLE MANUFACTURING SYSTEM (FMS) AND AUTOMATED GUIDED VEHICLE SYSTEM (AGVS)**	**9**
Types of Flexibility - FMS – FMS Components – FMS Application & Benefits – FMS Planning and Control – Quantitative analysis in FMS – Simple Problems. Automated Guided Vehicle System (AGVS) –		

AGVS Application – Vehicle Guidance technology – Vehicle Management & Safety.		
UNIT	**TITLE**	**PERIODS**
5	**INDUSTRIAL ROBOTICS**	**9**
Robot Anatomy and Related Attributes – Classification of Robots- Robot Control systems – End Effectors – Sensors in Robotics – Robot Accuracy and Repeatability - Industrial Robot Applications– Robot Part Programming – Robot Accuracy and Repeatability – Simple Problems.		
Case Study: Lights-out manufacturing – Zero Down Time		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Understand the basic concepts of CAD, CAM and computer integrated manufacturing Systems
CO2:	Summarize the production planning and control and computerized process planning
CO3:	Compare the different coding systems used in group technology and solve simple problems
CO4:	Interpret the concepts of flexible manufacturing system (FMS) and automated guided vehicle (AGV) system
CO5:	Analyze and select suitable robots for various Industrial applications based on their anatomy and attributes.

TEXT BOOKS:	
1.	Mikell.P.Groover “Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall of India, 2008
2.	Radhakrishnan P, Subramanyan S.and Raju V., “CAD/CAM/CIM”, 2nd Edition, New Age International (P) Ltd, New Delhi, 2000.

REFERENCE BOOKS:	
1.	Gideon Halevi and Roland Weill, “Principles of Process Planning – A Logical Approach” Chapman & Hall, London, 1995.
2.	Kant Vajpayee S, “Principles of Computer Integrated Manufacturing”, Prentice Hall India.
3.	Rao. P, N Tewari &T.K. Kundra, “Computer Aided Manufacturing”, Tata McGraw Hill Publishing Company, 2000.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE042T	**VEHICLE DESIGN ENGINEERING**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: 191MEC502T - MECHANICS OF MACHINES

COURSE OBJECTIVES:	
1.	To gain knowledge on Vehicle design and FMEA
2.	To familiarized with selection of engine and transmission
3.	To analyze force acting in crank mechanism
4.	To analyze vehicle vibrations
5.	To obtain knowledge on Standards, tests and norms for an automotive part/system

UNIT	TITLE	PERIODS
1	**TRANSLATION OF CUSTOMER'S VOICE INTO ENGINEERING REQUIREMENTS**	**9**
–Different phases of new product development, QFD, HoQ for converting customer voice into technical specifications, Casestudies–HoQfor cars/motorcycles, any part/subsystem. Failure Mode and Effects Analysis(FMEA), Failure analysis technique- FTA, kepner-trio, problem analysis etc. Kano status and athe import in design from conception to launch. Scrum techniques in NPD- Bench marking competitor evaluation		
UNIT	**TITLE**	**PERIODS**
2	**SELECTION OF ENGINE AND TRANSMISSION FOR AN AUTOMOBILE**	**9**
Merits and demerits of different vehicle layouts. Chassis frame design, Engine selection criteria, Matching engine and transmission, Transmission selection - over gearing and under gearing, Vehicle dynamics -ride and handling, vehicle stability, roll over protection, pedestrian protection- safety systems		
UNIT	**TITLE**	**PERIODS**
3	**FORCES ACTING IN CRANK MECHANISM**	**9**
Instantaneous piston velocity and acceleration, instantaneous connecting rod velocity and acceleration, Plotting P-ϴ, P-v diagrams, side thrust, resultant force, turning moment of single cylinder and multi-cylinder engines, various forces acting in crank mechanism.		
UNIT	**TITLE**	**PERIODS**
4	**VEHICLE VIBRATION**	**9**
Load distribution, spring stiffness at front and rear, vertical springs, inclined springs, springs in series, parallel springs, equivalent stiffness, Quarter car model and half car model, single and two degree of freedom systems - free and forced vibrations, damped and undamped vibrations, frequency, mode shapes, critical velocity, Transmissibility ratio, combined pitch and bounce, pitch centre and bounce centre		
UNIT	**TITLE**	**PERIODS**
5	**STANDARDS, TESTS AND NORMS FOR AN AUTOMOTIVE PART/SYSTEM**	**9**
Global material/design/regulatory & automotive standards for automobile industry - Working environment of		

part / sub system / vehicle in usage & handling by various stake holders – Tests & test conditions to verify part against all failure modes - case studies, Emission norms. Reliability and durability of vehicles.

	TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Incorporate customer requirements in new product development using FMEA and benchmarking techniques
CO2:	Select engine and matching transmission for better vehicle dynamics.
CO3:	Evaluate the forces acting in crank mechanism of engines.
CO4:	Analyze the load distribution and vibrations in vehicles.
CO5:	Deduce the automotive standards and norms for various working environments.

TEXT BOOKS:	
1.	N.K.Giri, “Automobile Mechanics”, 8thEdition, Khanna Publishers, Delhi,2013.
2.	Kirpal Singh, “Automobile Engineering”, Volume-1&2, 13thEdition, Standard Publishers Distributers, Delhi,2017.
3.	Thomas D.Gillespie, “Fundamentals of vehicle dynamics” Premiere Series Books, 1992.

REFERENCE BOOKS:	
1.	Harald Naunheimer, Bernd Bertsche, Joachim Ryborz, Wolfgang Novak, “Automotive Transmissions - Fundamentals, Selection, Design and Application”, in Collaboration with Peter Fietkau, Second Edition, Springer,2010
2.	G. K. Grover, “Mechanical Vibrations”, 8thEdition, Nem Chand & Bros, Rooekee, U.K., India, 2009.

<table>
<tr><td rowspan="3">Course Code

191MEE043T</td><td rowspan="3">Course Title

WASTE HEAT RECOVERY SYSTEMS</td><td colspan="4">Periods per week</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>R</td></tr>
<tr><td>**3**</td><td>**0**</td><td>**0**</td><td>**0**</td><td>**3**</td></tr>
</table>

PREREQUISITES: NIL

COURSE OBJECTIVES:

1.	To understand the underlying principles of Co-Generation.
2.	To gain knowledge in techno economics of Cogeneration and its application.
3.	To provide knowledge in waste heat recovery.
4.	To gain knowledge in various waste heat recovery systems.
5.	To gain knowledge in techno economics of Cogeneration and its application.

UNIT	TITLE	PERIODS
1	**CO-GENERATION**	**9**

Introduction-principles of thermodynamics, combined cycles, topping, bottoming, organic rankine cycles, advantages of cogeneration technology

UNIT	TITLE	PERIODS
2	**APPLICATION AND TECHNO ECONOMICS OF COGENERATION**	**9**

Cogeneration application in various industries like cement, sugar mill, paper mill etc. Sizing of waste heat boilers-performance calculations, part load characteristics, selection of co-generational technologies-financial considerations- operating and investments-costs of co-generation

UNIT	TITLE	PERIODS
3	**WASTE HEAT RECOVERY**	**9**

Introduction-principles of thermodynamics and second law- sources of waste heat recovery-diesel engines and power plant.

UNIT	TITLE	PERIODS
4	**WASTE HEAT RECOVERY SYSTEMS**	**9**

Recuperators, regenerators, economizers plate heat exchangers. Waste heat boilers-classification, location, service conditions and design considerations. Unfired combined cycle, supplementary fired combined cycle, fired combined cycle.

UNIT	TITLE	PERIODS
5	**APPLICATIONS AND TECHNO ECONOMICS OF WASTE HEAT RECOVERY**	**9**

Applications in industries-fluidized bed heat exchangers, heat pipe exchangers-heat pumps and thermic fluid heaters. Selection of waste heat recovery technologies-financial considerations, operations and investment costs of waste heat recovery

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Demonstrate the ability to select cogeneration systems.
CO2:	Calculate the thermodynamic parameter for a waste heat recovery system.
CO3:	Size cogeneration system for cement, sugar and paper industries by considering economic issues.
CO4:	Size components of heat recovery system with and without supplementary firing.
CO5:	Recover waste heat in FBC, heat pipe, heat pumps and thermic fluid heaters.

TEXT BOOKS:	
1.	Charles H Butler, “Co-generation”, Mc Graw Hill, New York,1984
2.	Horlock J H, “Co-generation-Heat and Power, Thermodynamics and Economics”, Oxford,UK, 1987.
3.	“Institute of Fuel, London, Waste Recovery”, Chapman and Hall Publishers, London,UK,1963.
4.	Sengupta Subrata, Lee SS EDS, “Waste Heat Utilization and Management”,Washington,USA,1983

REFERENCE BOOKS:	
1.	Robert Noyes, “Cogeneration of Steam and Electric Power, Energy Technology Review”, Vol:29, Noyes Data corporation, 1978.
2.	Stecher P G “Industrial and Institutional Waste Heat Recovery Energy, Technology Review”, No:37, Noyes Data Corporation 1978

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE044T	**HYDRO DYNAMICS**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To learn the basic measurement technique in Fluid mechanics.
2.	To provide extensive treatment of the operating principles and limitations of pressure and temperature measurements.
3.	To cover both operating and application procedures of hot wire anemometer.
4.	To describe flow visualization techniques and to highlight in depth discussion of analog methods.
5.	To understand the importance of special flows and error analysis.

UNIT	TITLE	PERIODS
1	**BASIC MEASUREMENTS IN FLUID MECHANICS**	**9**

Objective of experimental studies – Fluid mechanics measurements – Properties of fluids – Measuring instruments – Performance terms associated with measurement systems – Direct measurements - Analogue methods – Flow visualization – Components of measuring systems – Importance of model studies.

UNIT	TITLE	PERIODS
2	**WIND TUNNEL MEASUREMENTS**	**9**

Characteristic features, operation and performance of low speed, transonic, supersonic and special tunnels - Power losses in a wind tunnel – Instrumentation and calibration of wind tunnels – Turbulence- Wind tunnel balance – Wire balance – Strut-type – Platform-type – Yoke-type – Pyramid type – Strain gauge balance – Balance calibration.

UNIT	TITLE	PERIODS
3	**FLOW VISUALIZATION AND ANALOGUE METHODS**	**9**

Visualization techniques – Smoke tunnel – Hele-Shaw apparatus - Interferometer – Fringe Displacement method – Schlieren system – Shadowgraph - Hydraulic analogy – Hydraulic jumps – Electrolytic tank.

UNIT	TITLE	PERIODS
4	**PRESSURE, VELOCITY AND TEMPERATUREMEASUREMENTS**	**9**

Pitot - static tube characteristics - Velocity measurements - Hot-wire anemometry – Constant current and Constant temperature Hot-Wire anemometer – Pressure measurement techniques - Pressure transducers – Temperature measurements.

UNIT	TITLE	PERIODS

5	SPECIAL FLOWS AND UNCERTAINTY ANALYSIS	9
Experiments on Taylor-Proudman theorem and Ekman layer – Measurements in boundary layers - Data acquisition and processing – Signal conditioning – Uncertainty analysis – Estimation of measurement errors – External estimate of the error – Internal estimate of the error – Uncertainty calculation - Uses of uncertainty analysis.		

	TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Explain the knowledge on measurement techniques in aerodynamic flow.
CO2:	Analysis the Lift and drag measurements through various techniques in wind tunnel
CO3:	Apply the flow visualization technique to study flow pattern of aerodynamic model.
CO4:	Illustrate the Specific instruments for flow parameter measurement like pressure, velocity
CO5:	Apply the Wind tunnel boundary corrections and Scale effects

TEXT BOOKS:	
1.	Rathakrishnan, E., “Instrumentation, Measurements, and Experiments in Fluids,” CRC Press – Taylor & Francis, 2007.
2.	Robert B Northrop, “Introduction to Instrumentation and Measurements”, Second Edition, CRC Press, Taylor & Francis, 2006.

REFERENCE BOOKS:	
1.	Bradsaw "Experimental Fluid Mechanics", Elsevier, 2nd edition, 1970.
2.	Pope, A., and Goin, L., "High Speed Wind Tunnel Testing", John Wiley, 1985.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE045T	**BUILDING AUTOMATION SYSTEMS**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: ELECTRICAL AND AIR CONDITIONING

COURSE OBJECTIVES:	
1.	To enlighten the concept of Building Management System (BMS) and Automation.
2.	To familiarize with various transducers and sensors in BMS.
3.	To familiarize various controls in building automation system
4.	To expose on Control panel and Communication.
5.	To introduce Fire Alarm System (FAS) and security system such as CCTV.
6.	To apply Energy Management in Building Automation.

UNIT	**TITLE**	**PERIODS**
1	**INTRODUCTION TO BUILDING AUTOMATION SYSTEM**	**9**
Concept and application of Building Management System (BMS) and Automation, requirements and design considerations and its effect on functional efficiency of building automation system, architecture and components of BMS. Systems used in building automation system. Building heating and cooling system. Chiller, DX plant, Air handling unit, Fan coil unit, CAV and VAV System, Ventilation system, Lighting system, Water distribution, Plumbing System, Firefighting System, Lift, HVAC Control Panel, Electrical distribution System. MCC Panel components		
UNIT	**TITLE**	**PERIODS**
2	**SENSORS & ACTUATORS IN BAS**	**9**
Desirable properties of Sensors-Temperature Sensors: RTD, Thermistor, Thermocouple, Bimetallic strip - Pressure Sensors: Diaphragm type, piezoelectric sensors - Air flow sensor: Anemometer, velocity pressure sensors – Flow sensors: Turbine flow meter, Orifice, Venturi, Pitot tube, ultrasonic flow meter –Humidity sensors - Gas / air quality sensors - Electrical current monitoring sensors-Smoke sensors-Motion / occupancy sensors, Contact sensors . Sensors calibration Actuators used in BAS contactor, Electro Mechanical relay, Contactors, VFD, Stepper Motor, Valves, Dampers		
UNIT	**TITLE**	**PERIODS**
3	**CONTROL AND AUTOMATION**	**9**
Types of Control- open and closed loop control. On off control, Proportional, Integral, Derivative controller, PID control, Digital control, DDC system, Adaptive control, Optimal controls – AHU and Chiller Control;		

Optimization algorithms for chillers		
UNIT	**TITLE**	**PERIODS**
4	**NETWORKING AND COMMUNICATION**	**9**
Communication Basics, Networks, systems- LAN networks. BAS communication Standards, BACNet, Modbus, LON- Wireless sensor. Internet technologies		
UNIT	**TITLE**	**PERIODS**
5	**LIGHTING, FAS, SECURITY SYSTEMS & ENERGY MANAGEMENT**	**9**
Fire, Fire modes – Fire Alarm Systems components: Field components, panel components – FAS Architectures – Access Components, Access control system Design - CCTV camera types and operation – camera selection criteria – CCTV Applications. Energy Savings concept & methods, lightning control.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Demonstrate the ability to identify various components of building automation systems
CO2:	Select the correct type of sensor for a building automation system
CO3:	Choose various types of controls and optimization algorithms for cooling system
CO4:	Derive the control panel and communication system for building automation systems
CO5:	Derive the lighting, fire alarm system and security system for building automation systems
CO6:	Implement the green building concepts for improving the building efficiency

TEXT BOOKS:	
1.	Bela G. Liptak, Process control – Instrument Engineers Handbook Chilton book co.
2.	Reinhold A. Carlson and Robert A. Di Giandomenico, Understanding Building Automation Systems (Direct Digital Control, Energy Management, Life safety, Security, Access Control, Lightning, Building Management Programs) (Hardcover),., 1991
3.	Shengwei Wang - Intelligent Buildings and Building Automation- Spon Press
4.	WaiLok Chan, Intelligent Building Systems by Albert Ting-Pat So, Kluwer Academic publisher, 3rd ed., 2012.

REFERENCE BOOKS:	
1.	Building Control Systems, Application Guide (CIBSE Guide), CIBSE, 2000.
2.	Jim Sinopoli, Butterworth-Heinemann,Smart Buildings by imprint of Elsevier, 2nd ed., 2010.
3.	Robert Gagnon, Design of Special Hazards and Fire Alarm Systems, 2007.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE046T	**IOT FOR MECHANICAL ENGINEERING**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To gain a basic knowledge of IoT and its application in Mechanical Engineering.
2.	To present a problem oriented in depth knowledge of IoT & Smart Manufacturing
3.	To address the underlying concepts and methods behind Database Management.
4.	To address various problems related to IoT enabled Industries.
5	To understand the concepts of security and privacy issues related to IoT.

UNIT	TITLE	PERIODS
1	**THE INTERNET OF THINGS: AN OVERVIEW**	**9**

The Internet of Things: An overview; Design Principles for Connected Devices; Internet Principles. Thinking about Prototyping – Costs versus ease of prototyping, prototyping and Production, open source versus Closed Source. Prototyping Embedded devices – Electronics, Embedded Computing Basics, Arduino/ Raspberry Pi/ BeagleBone Black/ etc., Electric Imp and other notable platforms Prototyping of Physical Design. Prototyping online Components – Getting Started with an API, Writing a New API.

UNIT	TITLE	PERIODS
2	**DATABASE MANAGEMENT**	**9**

Real Time Reactions, Other Protocols. Techniques for Writing Embedded Code – Memory Management, Performance and Battery Life, Libraries and debugging. Automatic Storage Management in a Cloud World – Introduction to Cloud, Relational Databases in the Cloud, Automatic Storage Management in the Cloud. Smart Connected System Design Case Study.

UNIT	TITLE	PERIODS
3	**IOT AND ITS SECURITY**	**9**

Internet of Things Privacy, Security and Governance Introduction, Overview of Governance, Privacy and Security Issues, Contribution from FP7 Projects, Security, Privacy and Trust in IoT-Data-Platforms for Smart Cities, First Steps Towards a Secure Platform, Smartie Approach. Data Aggregation for the IoT in Smart Cities, Security.

UNIT	TITLE	PERIODS
4	**SMART MANUFACTURING**	**9**

Introduction to Smart Manufacturing: What is “smart manufacturing” really and how does it differ from conventional/legacy manufacturing-Smart Manufacturing Processes- Three Dimensions: (1) Demand Driven and Integrated Supply Chains;(2) Dynamically Optimized Manufacturing Enterprises (plant + enterprise operations);(3) Real Time, Sustainable Resource Management (intelligent energy demand management,

production energy optimization and reduction of GHG), Smart Applications: Online Predictive Modeling, Monitoring and Intelligent Control of Machining/Manufacturing .		
UNIT	**TITLE**	**PERIODS**
5	**SMART SUPPLY CHAIN MANAGEMENT**	**9**
Logistics/Supply Chain Processes, Smart Transportation - Digital Tools, Product Representation and Exchange Technologies and Standards, Agile (Additive) Manufacturing Systems and Standards. Mass Customization, Smart Machine Tools, Robotics and Automation (perception, manipulation, mobility, autonomy), Smart Perception – Sensor networks and Devices. Smart warehouse Management of processes and facilities.		
Case studies: Improving Intelligent Decision Making under uncertainty Assisted/Augmented Production, Assisted/Augmented Assembly, Assisted/Augmented Quality, Assisted/Augmented Maintenance, Assisted/Augmented Warehouse Operations and Assisted Training.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, Students will be able to	
CO1:	Apply concept of IoT and its application in Mechanical Engineering.
CO2:	Select the appropriate methods in Database Management.
CO3:	Classify the problems related to IoT enabled Industries.
CO4:	Apply the concepts of security and privacy issues related to IoT.
CO5:	Apply the supply chain management concept in Industrial automation

TEXT BOOKS:	
1.	A. McEwen and H. Cassimally, Designing the Internet of Things, 1st edition, Wiley, 2013, ISBN-10: 111843062X.
2.	N. Vengurlekar and P. Bagal, Database Cloud Storage: The Essential Guide to Oracle Automatic Storage Management, 1st edition, McGraw-Hill Education, 2013, ISBN-10: 0071790152.

REFERENCE BOOKS:	
1.	M. Kuniavsky, Smart Things: Ubiquitous Computing User Experience Design, 1st edition, Morgan Kaufmann, 2010, ISBN-10: 0123748992.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE047T	**PROCESS PLANNING AND COST ESTIMATION**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To understand the Selection of process, equipment and tools for various industrial products.
2.	To study and prepare process planning activity chart.
3.	To understand the concept of cost estimation.
4.	To know the compute job order cost for different types of shop floor.
5.	To develop the knowledge in calculating machining time for various machining operations.

UNIT	**TITLE**	**PERIODS**
1	**INTRODUCTION TO PROCESS PLANNING**	**9**
Introduction- methods of process planning-Drawing interpretation-Material evaluation – steps in process selection-.Production equipment and tooling selection		
UNIT	**TITLE**	**PERIODS**
2	**PROCESS PLANNING ACTIVITIES**	**9**
Process parameters calculation for various production processes-Selection jigs and fixtures election of quality assurance methods – Set of documents for process planning-Economics of process planning- case studies		
UNIT	**TITLE**	**PERIODS**
3	**INTRODUCTION TO COST ESTIMATION**	**9**
Importance of costing and estimation –methods of costing-elements of cost estimation –Types of estimates – Estimating procedure- Estimation labor cost, material cost- allocation of over head charges- Calculation of depreciation cost		
UNIT	**TITLE**	**PERIODS**
4	**PRODUCTION COST ESTIMATION**	**9**
Estimation of Different Types of Jobs – Estimation of Forging Shop, Estimation of Welding Shop, Estimation of Foundry Shop		
UNIT	**TITLE**	**PERIODS**
5	**MACHINING TIME CALCULATION**	**9**
Estimation of Machining Time – Importance of Machine Time Calculation- Calculation of Machining Time for Different Lathe Operations ,Drilling and Boring – Machining Time Calculation for Milling, Shaping and Planning -Machining Time Calculation for Grinding.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Select the production tools and equipments for various Industrial Products.
CO2:	Calculate the process parameters and planning activities for various production processes.
CO3:	Evaluate the various elements of costing and estimation
CO4:	Calculate the cost estimation for various production process in Shop Floors.
CO5:	Estimate the machining time for various manufacturing operations.

TEXT BOOKS:	
1.	Peter scalon, "Process planning, Design/Manufacture Interface", Elsevier science technology Books, Dec 2002.
2.	Sinha B.P, "Mechanical Estimating and Costing", Tata-McGraw Hill publishing co, 1995.

REFERENCE BOOKS:	
1.	Chitale A.V. and Gupta R.C., "Product Design and Manufacturing", 2nd Edition, PHI, 2002.
2.	K.C. Jain & L.N. Aggarwal, "Production Planning Control and Industrial Management", Khanna Publishers 1990.
3.	Mikell P. Groover, "Automation, Production, Systems and Computer Integrated Manufacturing", Pearson Education 2001.
4	Ostwalal P.F. and Munez J., "Manufacturing Processes and systems", 9th Edition, John Wiley, 1998.
5	R Kesavan, C . Elanchezhian,B.Vijaya Ramnath, "Process Planning and Cost Estimation", New Age International Publishers, 2019.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE051T	**FAILURE ANALYSIS AND NDT TECHNIQUES**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES:

COURSE OBJECTIVES:	
1.	To introduce need and scope of failure analysis and fundamental sources of failures.
2.	To learn about non-destructive testing and basic principles of visual inspection.
3.	To study about magnetic testing and principles, techniques.
4.	To learn the principle of radiography testing and its inspection techniques and methods.
5.	To study the acoutistic testing principle and technique and instrumentation.

UNIT	TITLE	PERIODS
1	**INTRODUCTION**	**9**
Introduction and need and scope of failure analysis. Engineering Disasters and understanding failure analysis. Fundamental sources of failures. Deficient design. Improper Manufacturing & Assembly. Tree diagram and FMEA.		
UNIT	**TITLE**	**PERIODS**
2	**VISUAL INSPECTION**	**9**
Introduction to Non-Destructive Testing: An Introduction, Visual examination, Basic Principle, The Eye, Optical aids used for visual inspection, Applications. Liquid Penetrant Testing: Physical principles, Procedure for penetrant testing, Penetrant testing materials, Penetrant testing methods, Sensitivity, Applications, Limitations and Standards		
UNIT	**TITLE**	**PERIODS**
3	**MAGNETIC TESTING**	**9**
Magnetic Particle Testing, Eddy Current Testing: Magnetism-basic definitions and principle of. magnetic particle testing, Magnetizing techniques, induced current flow, Procedure used for testing a component, Equipment Used for magnetic particle testing, Sensitivity, Limitations. Eddy Current Testing: Principles, Instrumentation for eddy current testing Techniques. Sensitivity Advanced Eddy Current Test Methods, Applications, Limitations.		
UNIT	**TITLE**	**PERIODS**
4	**RADIOGRAPHY TESTING**	**9**
Radiography, Ultrasonic Testing: Basic principle, Electromagnetic radiation, Sources, Radiation attenuation in the specimen. Effect of radiation in film, Radiographic imaging, Inspection techniques, Applications of radiographic inspection, Limitations, Safety in Industrial Radiography, Standards, Neutron radiography. Ultrasonic Testing: Basic properties of sound beam, Ultrasonic transducers, Inspection methods, Techniques for Normal Beam Inspection,		

Techniques for Angle Beam Inspection, Flaw characterization techniques, Ultrasonic flaw detection equipment, Modes of Display, Immersion Testing, Applications of Ultrasonic Testing, Advantages, Limitations		
UNIT	**TITLE**	**PERIODS**
5	**ACOUTISTIC TESTING**	**9**
Acoustic Emission Testing: Principle of Acoustic Emission Testing, Technique, Instrumentation, Sensitivity, Applications, Standards. Thermograph: Basic Principles, Detectors and Equipment, Techniques, Applications, Codes and Standards. In Situ Metallographic Examination: Approach to the Selection of Site for Metallographic examination, Replication process, Significance of Microstructure observation, Decision making, Applications, Codes and Standards.(digital signal process)		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Discuss the need and scope of failure analysis and fundamental sources of failures.
CO2:	Describe about non-destructive testing and basic principles of visual inspection.
CO3:	Explain about magnetic testing and principles, techniques.
CO4:	Explain the principle of radiography testing and its inspection techniques and methods.
CO5:	Describe the acoutistic testing principle and technique and instrumentation.

TEXT BOOKS:	
1.	Baldev Raj, T.Jayakumar, M.Thavasimuthu Practical Non-Destructive Testing, Narosa Publishing House, 2014.
2.	Ravi Prakash, Non-Destructive Testing Techniques, 1st revised edition, New Age International Publishers, 2010

REFERENCE BOOKS:	
1.	ASM Metals Handbook,Non-Destructive Evaluation and Quality Control, American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
2.	ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook, Vol. 1,Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4,Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7,Ultrasonic Testing
3.	Charles, J. Hellier, Handbook of Non destructive evaluation, McGraw Hill, New York 2001.
4.	Paul E Mix, Introduction to Non-destructive testing: a training guide, Wiley, 2nd Edition NewJersey, 2005

5.	J.Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-HillEducation, 2nd edition (2011).

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Course Title</td><td colspan="4">Periods per week</td><td rowspan="2">Credits</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>R</td></tr>
<tr><td>**191MEE052T**</td><td>**ERGONOMICS IN DESIGN**</td><td>**3**</td><td>**0**</td><td>**0**</td><td>**0**</td><td>**3**</td></tr>
</table>

PREREQUISITES:

COURSE OBJECTIVES:	
1.	To introduce to industrial design based on ergonomics.
2.	To consider ergonomics concept in manufacturing
3.	To apply ergonomics in design of controls and display.
4.	To apply environmental factors in ergonomics design.
5.	To develop aesthetics applicable to manufacturing and product

UNIT	**TITLE**	**PERIODS**
1	**INTRODUCTION**	**9**

An approach to industrial design, Elements of design structure for industrial design in engineering application in modern manufacturing systems- Ergonomics and Industrial Design: Introduction to Ergonomics, Communication system, general approach to the man-machine relationship, Human component of work system, Machine component of work system, Local environment-light, Heat, Sound.

UNIT	**TITLE**	**PERIODS**
2	**ERGONOMICS AND PRODUCTION**	**9**

Introduction, Anthropometric data and its applications in ergonomic, working postures, Body Movements, Work Station Design, Chair Design. Visual Effects of Line and Form: The mechanics of seeing, Psychology of seeing, Figure on ground effect, Gestalt's perceptions - Simplicity, Regularity, Proximity, Wholeness. Optical illusions, Influences of line and form.

UNIT	**TITLE**	**PERIODS**
3	**DESIGN PRINCIPLES FOR DISPLAY AND CONTROLS**	**9**

Displays: Design Principles of visual Displays, Classification, Quantitative displays, Qualitative displays, check readings, Situational awareness, Representative displays, Design of pointers, Signal and warning lights, colour coding of displays, Design of multiple displays Controls: Design considerations, Controls with little efforts – Push button, Switches, rotating Knobs. Controls with muscular effort – Hand wheel, Crank, Heavy lever, Pedals. Design of controls in automobiles, Machine Tools

UNIT	**TITLE**	**PERIODS**
4	**ENVIRONMENTAL FACTORS**	**9**

Colour: Colour and light, Colour and objects, Colour and the eye – after Image, Colour blindness, Colour constancy, Colour terms – Colour circles, Munsel colour notation, reactions to colour and colour combination – colour on engineering equipments, Colour coding, Psychological effects,

colour and machine form, colour and style		
UNIT	**TITLE**	**PERIODS**
5	**AESTHETIC CONCEPTS**	**9**
Concept of unity, Concept of order with variety, Concept of purpose, Style and environment, Aesthetic expressions - Symmetry, Balance, Contrast, Continuity, Proportion. Style - The components of style, House style, Style in capital good. Introduction to Ergonomic and plant layout software's, total layout design.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Appreciate ergonomics need in the industrial design.
CO2:	Apply ergonomics in creation of manufacturing system
CO3:	Discuss on design of controls and display.
CO4:	Consider environmental factors in ergonomics design.
CO5:	Report on importance of aesthetics to manufacturing system and product

TEXT BOOKS:	
1.	Ergonomics in Design: Methods and Techniques (Human Factors and Ergonomics) by Marcelo M. Soares , Francisco Rebelo
2.	Ergonomics in Product Design by Sendpoints Publishing Co. Ltd.

REFERENCE BOOKS:	
1.	Benjamin W.Niebel, Motion and Time Study, Richard, D. Irwin Inc., 7thEdition, 2002
2.	Brain Shakel,"Applied Ergonomics Hand Book", Butterworth Scientific London 1988.
3.	Bridger, R.C., Introduction to Ergonomics, 2ndEdition, 2003, McGraw Hill Publications.
4.	Martin Helander, A Guide to human factors and Ergonomics, Taylor and Francis, 2006
5.	Mayall W.H. "Industrial design for Engineers", London Hiffee books Ltd., 1988.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE053T	**CRYOGENIC ENGINEERING**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: Engineering Thermodynamics, Thermal Engineering

COURSE OBJECTIVES:	
1.	To provide introductory knowledge of cryogenic Engineering
2.	To impart knowledge in liquefaction, separation of cryogenics gases and working of cryocoolers
3.	To provide knowledge in separation of cryogenic gases.
4.	To gain knowledge in different types of refrigerators.
5.	To provide awareness on handling of various cryogenic systems.

UNIT	TITLE	PERIODS
1	**INTRODUCTION**	**8**
Insight on Cryogenics, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures. Applications of Cryogenics in Space Programs, Superconductivity, Cryo Metallurgy, Medical applications.		
UNIT	**TITLE**	**PERIODS**
2	**LIQUEFACTION CYCLES**	**10**
Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve - Joule Thomson Effect. Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claudes Cycle Dual Cycle, Ortho- Para hydrogen conversion, Eollins cycle, Simpson cycle, Critical Components in Liquefaction Systems.		
UNIT	**TITLE**	**PERIODS**
3	**SEPARATION OF CRYOGENIC GASES**	**9**
Binary Mixtures, T-C and H-C Diagrams, Principle of Rectification, Rectification Column Analysis - McCabe Thiele Method. Adsorption Systems for purification		
UNIT	**TITLE**	**PERIODS**
4	**CRYOGENIC REFRIGERATORS**	**8**
J.T.Cryocoolers, Stirling Cycle Refrigerators, G.M.Cryocoolers, Pulse Tube Refrigerators Regenerators used in Cryogenic Refrigerators, Dilution refrigerators, Magnetic Refrigerators		
UNIT	**TITLE**	**PERIODS**
5	**HANDLING OF CRYOGENS**	**10**
Cryogenic Dewar, Cryogenic Transfer Lines. Insulations used in Cryogenic Systems, Instrumentation to measure Flow, Level and Temperature		
Case studies: Material selection of cryogenic pressure vessel in industry. Study of chandrayaan 2 by GSLV-MKIII launch vehicle system.		
	TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Calculate cryogenic properties of fluid and materials.
CO2:	Select cycle for gas liquefaction
CO3:	Correlate the separation techniques of cryogenic gases and sketch phase diagrams.
CO4:	Select cryogenic cooling equipment for particular applications
CO5:	Implement safety procedures while handling cryogens

TEXT BOOKS:	
1.	Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985
2.	Scott R.B., Cryogenic Engineering, Van No strand and Co., 1962
3.	Venkatarathnam G, Cryogenic Mixed Refrigerant Processes, Springer Publication, 2010.

REFERENCE BOOKS:	
1.	Herald Weinstock, Cryogenic Technology, Boston Technical Publishers, inc., 1969
2.	J.G.Weisend, Hand Book of Cryogenic Engineering —II, Taylor and Francis, 1998.
3.	Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press, New York, 1989
4.	Robert W. Vance, Cryogenic Technology, John wiley & Sons, Inc., New York, London

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE054T	**MICRO FLUIDICS**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To learn the basics of micro fluidics
2.	To understand the concepts of micro scale fluid mechanics and capillary flows
3.	To get exposure on electro kinetics.
4.	To learn the micro fabrication techniques
5.	To know the components used in micro fluidics fabrication

UNIT	TITLE	PERIODS
1	**INTRODUCTION**	**5**
Origin, Definition, Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws.		
UNIT	**TITLE**	**PERIODS**
2	**MICRO-SCALE FLUID MECHANICS- CAPILLARY FLOWS**	**10**
Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations. Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects. Exact solutions, Couette flow, Poiseuille flow, Stokes drag on a sphere, Time-dependent flows, Two-phase flows, Thermal transfer in microchannels. Hydraulic resistance and Circuit analysis, Straight channel of different cross-sections, Channels in series and parallel. Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length and capillary rise, Interfacial boundary conditions, Marangoni effect.		
UNIT	**TITLE**	**PERIODS**
3	**ELECTRO KINETICS**	**10**
Electro hydro dynamics fundamentals. Electro-osmosis, Debye layer, Thin ED Limit, Ideal electroosmotic flow, Ideal EOF with back pressure, Cascade electroosmotic micro pump, EOF of power-law fluids. Electrophoresis of particles, Electrophoretic mobility, Electrophoretic velocity dependence on particle size. Di electrophoresis, Induced polarization and DEP, Point dipole in a dielectric fluid, DEP force on a dielectric sphere, DEP particle trapping, AC DEP force on a dielectric sphere. Electro-capillary effects, Continuous electro-wetting, Direct electro-wetting, Electro-wetting on dielectric.		
UNIT	**TITLE**	**PERIODS**
4	**MICROFABRICATION TECHNIQUES**	**8**

Materials, Clean room, Silicon crystallography, Miller indices. Oxidation, photolithography- mask, spin coating, exposure and development, Etching, Bulk and Surface micromachining, Wafer bonding. Polymer microfabrication, PMMA/COC/PDMS substrates, micro molding, hot embossing, fluidic interconnections.

UNIT	TITLE	PERIODS
5	MICRO FLUIDICS COMPONENTS	12

Micropumps, Check-valve pumps, Valve-less pumps, Peristaltic pumps, Rotary pumps, Centrifugal pumps, Ultrasonic pump, EHD pump, MHD pumps. Micro valves, Pneumatic valves, Thermo pneumatic valves, Thermomechanical valves, Piezoelectric valves, Electrostatic valves, Electromagnetic valves, Capillary force valves. Microflow sensors, Differential pressure flow sensors, Drag force flow sensors, Lift force flow sensors, Coriolis flow sensors, Thermal flow sensors. Micromixers, Physics of mixing, Pe-Re diagram of micromixers, Parallel lamination, Sequential lamination, Taylor-Aris dispersion. Droplet generators, Kinetics of a droplet, Dynamics of a droplet, In-channel dispensers, T-junction and Cross-junction, Droplet formation, breakup and transport. Microparticle separator, principles of separation and sorting of microparticles, design and applications. Microreactors, Design considerations, Liquid-phase reactors, PCR, Design consideration for PCR reactors.

TOTAL PERIODS:	**45**

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1:	Explain the benefits and applications of micro fluidics.
CO2:	Apply the knowledge of fluid mechanics to micro fluidics
CO3:	Analyze the kinetics of micro fluidics
CO4:	Practice various techniques to fabricate micro fluidics
CO5:	Design the various microfluidic components including micropumps, micromixers, microvalves etc.

TEXT BOOKS:

1.	Nguyen, N. T., Werely,S. T., Fundamentals and applications of Microfluidics,Artech house Inc., 2002.
2.	Bruus, H., Theoretical Microfluidics, Oxford University Press Inc., 2008.

REFERENCE BOOKS:

1.	Madou, M. J., Fundamentals of Microfabrication, CRC press, 2002.
2.	Tabeling,P., Introduction to microfluidics, Oxford University Press Inc., 2005
3.	Kirby,B.J., Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, Cambridge

	University Press, 2010.
4.	Colin,S., Microfluidics, John Wiley & Sons, 2009.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE055T	**HYBRID AND ELECTRICAL VEHICLE TECHNOLOGY**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: 191MEC603T - Automobile Engineering

COURSE OBJECTIVES:	
1.	To understand the fundamentals of electric vehicles.
2.	To learn about the concepts of hybrid vehicles.
3.	To understand the electric propulsion systems.
4.	To gain knowledge about energy storage devices.
5.	To gain knowledge about fuel cell and solar power.

UNIT	TITLE	PERIODS
1	**ELECTRIC VEHICLES**	**9**
Architecture of an electric vehicle, essentials and performance of electric vehicles – Traction motor characteristics, tractive effort, transmission requirements, vehicle performance, energy consumption, advantage and limitations.		
UNIT	**TITLE**	**PERIODS**
2	**HYBRID VEHICLES**	**9**
Hybrid electric drive trains - Concepts, architecture, design, control strategies, merits and demerits.		
UNIT	**TITLE**	**PERIODS**
3	**ELECTRIC PROPULSION SYSTEMS**	**9**
DC motor drives, induction motor drives, permanent magnet motor drives and switched reluctance motor drives.		
UNIT	**TITLE**	**PERIODS**
4	**ENERGY STORAGE DEVICES**	**9**
Electrochemical batteries – Reactions, thermodynamic voltage, lead-acid batteries, nickel based batteries, lithium based batteries, flywheel and ultra-capacitors, Battery management systems.		
UNIT	**TITLE**	**PERIODS**
5	**HYBRID SOLAR VEHICELS**	**9**
Fuel cell thermodynamics, operating principle, fuel cell technologies, fuel reforming, hydrogen production and storage. Photovoltaic cell, maximum power point tracking, solar powered accessories, hybrid solar vehicles.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Select the capacity of the electric vehicle traction motor based on performance characteristics
CO2:	Design the drive train for electric vehicles
CO3:	Select the motor drives for an electric vehicles.
CO4:	Select the battery storage device and storage management system for electric vehicles
CO5:	Incorporate the hybrid and solar technologies in electric vehicles.

TEXT BOOKS:	
1.	Iqbal Husain, “Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2011.
2.	Mehrdad Ehsani, Yimin Gao, sebastian E. Gay and Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2009.

REFERENCE BOOKS:	
1.	Aulice Scibioh M. and Viswanathan B., “Fuel Cells – Principles and Applications”, University Press, India, 2006.
2.	Barbir F., “PEM Fuel Cells: Theory and Practice” Elsevier, Burlington, 2005.
3.	James Larminie and John Loury, “Electric Vehicle Technology-Explained”, John Wiley & Sons Ltd., 2003.
4.	Seref Soylu “Electric Vehicles - The Benefits and Barriers”, InTech Publishers, Croatia, 2011.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE056T	**DRONE TECHNOLOGY**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To understand the basics of drone concepts
2.	To learn and understand the fundaments of design, fabrication and programming of drone
3.	To impart the knowledge of a flying and operation of drone
4.	To know about the various applications of drone
5.	To understand the safety risks and guidelines of fly safely

UNIT	TITLE	PERIODS
1	**INTRODUCTION TO DRONE TECHNOLOGY**	**9**
Drone Concept - Vocabulary Terminology- History of drone - Types of current generation of drones based on their method of propulsion- Drone technology impact on the businesses- Drone business through entrepreneurship- Opportunities/applications for entrepreneurship and employability		
UNIT	**TITLE**	**PERIODS**
2	**DRONE DESIGN, FABRICATION AND PROGRAMMING**	**9**
Classifications of the UAV -Overview of the main drone parts- Technical characteristics of the parts -Function of the component parts -Assembling a drone- The energy sources- Level of autonomy- Drones configurations -The methods of programming drone- Download program - Install program on computer- Running Programs- Multi rotor stabilization- Flight modes -Wi-Fi connection.		
UNIT	**TITLE**	**PERIODS**
3	**DRONE FLYING AND OPERATION**	**9**
Concept of operation for drone -Flight modes- Operate a small drone in a controlled environmentDrone controls Flight operations –management tool –Sensors-Onboard storage capacity - Removable storage devices- Linked mobile devices and applications		
UNIT	**TITLE**	**PERIODS**
4	**DRONE COMMERCIAL APPLICATIONS**	**9**
Choosing a drone based on the application -Drones in the insurance sector- Drones in delivering mail, parcels and other cargo- Drones in agriculture- Drones in inspection of transmission lines and power distribution -Drones in filming and panoramic picturing		
UNIT	**TITLE**	**PERIODS**
5	**FUTURE DRONES AND SAFETY**	**9**
The safety risks- Guidelines to fly safely -Specific aviation regulation and standardization- Drone license- Miniaturization of drones- Increasing autonomy of drones -The use of drones in swarms		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Know about a various type of drone technology, drone fabrication and programming.
CO2:	Execute the suitable operating procedures for functioning a drone.
CO3:	Select appropriate sensors and actuators for Drones
CO4:	Develop a drone mechanism for specific applications
CO5:	Create the programs for various drones

TEXT BOOKS:	
1.	Daniel Tal and John Altschuld, “Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation”, 2021 John Wiley & Sons, Inc.
2.	Terry Kilby and Belinda Kilby, “Make:Getting Started with Drones “,Maker Media, Inc, 2016

REFERENCE BOOKS:	
1.	John Baichtal, “Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs”, Que Publishing, 2016
2.	Zavrsnik, “Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance”, Springer, 2018.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE057T	**SUPPLY CHAIN MANAGEMENT AND LOGISTICS**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To provide an insight on the fundamentals of supply chain networks, tools and techniques
2.	To address the sourcing and analysis and strategic building concepts and methods behind Supply chain management and Logistics.
3.	To understand the role of Logistics in Supply chain management.
4.	To educate the importance of Information technology in Supply chain management.
5.	To understand the concept of network design in supply chain.

UNIT	TITLE	PERIODS
1	**INTRODUCTION**	**9**
Role of Logistics and Supply chain Management: Scope and Importance- Evolution of Supply Chain - Decision Phases in Supply Chain - Competitive and Supply chain Strategies – Drivers of Supply Chain Performance and Obstacles-Implementation.		
UNIT	**TITLE**	**PERIODS**
2	**SUPPLY CHAIN NETWORK DESIGN**	**9**
Role of Distribution in Supply Chain – Factors influencing Distribution network design – Design options for Distribution Network Distribution Network in Practice-Role of network Design in Supply Chain – Framework for network Decisions		
UNIT	**TITLE**	**PERIODS**
3	**LOGISTICS IN SUPPLY CHAIN**	**9**
Role of transportation in supply chain – factors affecting transportations decision – Routing and scheduling in transportation- Risk Pooling and postponement strategy, inventory management.		
UNIT	**TITLE**	**PERIODS**
4	**SOURCING AND COORDINATION IN SUPPLY CHAIN**	**9**
Role of sourcing supply chain supplier selection assessment and contracts- Design collaboration - sourcing planning and analysis - supply chain co-ordination - Bull whip effect – Effect of lack of co-ordination in supply chain and obstacles – Building strategic partnerships and trust within a supply chain. Beer game strategy – Case Study		
UNIT	**TITLE**	**PERIODS**
5	**SUPPLY CHAIN AND INFORMATION TECHNOLOGY**	**9**
The role IT in supply chain- The supply chain IT frame work Customer Relationship Management – Internal supply chain management – supplier relationship management – future of IT in supply chain –E-Business in supply chain.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, Students will be able to;	
CO1:	Apply various decisions phases and strategies for improving supply chain performance of an organization.
CO2:	Construct suitable network design for increasing Supply chain performance.
CO3:	Develop suitable logistics network design for Transportation in Supply chain.
CO4:	Choose appropriate sourcing and coordination contracts with supplier for building strategic partnerships and trust within a supply chain.
CO5:	Integrate IT tools in current trends with Internal and supplier relationship management.

TEXT BOOKS:	
1.	Janat Shah ,Supply Chain Management 2/e: Text and Cases ,Pearson Education,2016.
2.	Sunil Chopra, Peter Meindl and Kalra, “Supply Chain Management, Strategy, Planning, and operation”, Pearson Education, 2010.

REFERENCE BOOKS:	
1.	David J.Bloomberg , Stephen Lemay and Joe B.Hanna, “Logistics”, PHI 2002.
2.	David Simchi-Levi and Philip Kaminsky and Edith Simchi-Levi,Designing And Managing the Supply Chain: Concepts, Strategies and Case studies | 3rd Edition,2008.
3.	James B.Ayers, “Handbook of Supply chain management”, St.Lucle press, 2000.
4.	Jeremy F.Shapiro, “Modeling the supply chain”, Thomson Duxbury, 2002.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE061T	**ADDITIVE MANUFACTURING**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To learn principle, methods for Additive Manufacturing technologies
2.	To gain knowledge in various possibilities and Design process for Additive Manufacturing with suitable applications.
3.	To provide knowledge in environmental effects of Additive Manufacturing technologies and its applications.
4.	To gain knowledge familiar with the characteristics of the different materials those are used in Additive Manufacturing technologies.
5.	To learn about modern developments and case studies Additive Manufacturing process.

UNIT	**TITLE**	**PERIODS**
1	**INTRODUCTION**	**9**
Overview – Need - Development of Additive Manufacturing Technology -Principle – AM Process Chain-Classification –Rapid Prototyping- Rapid Tooling – Rapid Manufacturing – Applications Benefits –Case studies – Reverse Engineering		
UNIT	**TITLE**	**PERIODS**
2	**DESIGN FOR ADDITIVE MANUFACTURING**	**9**
Design tools: Data processing - CAD model preparation – Part orientation and support structure generation – Model slicing –Tool path generation- Design for Additive Manufacturing: Concepts and objectives- AM unique capabilities – DFAM for part quality improvement- Customized design and fabrication for medical applications.		
UNIT	**TITLE**	**PERIODS**
3	**PHOTOPOLYMERIZATION AND POWDER BED FUSION PROCESSES**	**9**
Photo polymerization: SLA-Photo curable materials – Process - Advantages and Applications. Powder Bed Fusion: SLS-Process description – powder fusion mechanism – Process Parameters – Typical Materials and Application- Electron Beam Melting.		
UNIT	**TITLE**	**PERIODS**
4	**EXTRUSION BASED AND SHEET LAMINATION PROCESSES**	**9**
Extrusion Based System: FDM-Introduction – Basic Principle – Materials – Applications and Limitations – Bio extrusion. Sheet Lamination Process: LOM- Gluing or Adhesive bonding – Thermal bonding.		
UNIT	**TITLE**	**PERIODS**
5	**PRINTING PROCESSES AND BEAM DEPOSITION PROCESSES**	**9**
Droplet formation technologies – Continuous mode – Drop on Demand mode – Three Dimensional Printing –		

Advantages – Bio plotter - Beam Deposition Process: LENS- Process description – Material delivery – Process parameters – Materials – Benefits – Applications.
Case Study: Customized implants and prosthesis

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Demonstrate a basic technical understanding of the physical principles, materials, and operation of the types of AM processes.
CO2:	Apply CAD tools for design and prototyping
CO3:	Select an appropriate powder fusion process for industrial applications
CO4:	Identify characteristics of parts that are fabricated by extrusion and lamination process
CO5:	Analyze the process parameters in beam deposition method

TEXT BOOKS:	
1.	Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", Third edition, World Scientific Publishers, 2010.
2.	Ian Gibson, David W.Rosen, Brent Stucker "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing" Springer , 2010.
3.	Serope Kalpakjian and Stephen Schmid,"Manufacturing, Engineering and Technology", SI 6th Edition -", Pearson Education, 2010.

REFERENCE BOOKS:	
1.	Andreas Gebhardt "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing" Hanser Gardner Publication 2011.
2.	Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, 2006.
3.	Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007.
4.	Tom Page "Design for Additive Manufacturing" LAP Lambert Academic Publishing, 2012.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE062T	**INDUSTRIAL LAYOUT DESIGN AND SAFETY**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To know the safety rules and regulations, standards and codes.
2.	To study various mechanical machines and their safety importance
3.	To understand the principles of machine guarding and operation of protective devices.
4.	To know the working principle of mechanical engineering processes such as metal forming and joining process and their safety risks
5.	Developing the knowledge related to health and welfare measures in engineering industry.

UNIT	TITLE	PERIODS
1	**SAFETY IN METAL WORKING MACHINERY AND WOOD WORKING MACHINES**	**9**
General safety rules – principles, maintenance, Inspections of turning machines, boring machines, milling machine, planning machine and grinding machines – CNC machines – Wood working machinery – types, safety principles, electrical guards, work area, material handling, inspection, standards and codes - saws, types, hazards.		
UNIT	**TITLE**	**PERIODS**
2	**PRINCIPLES OF MACHINE GUARDING**	**9**
Guarding during maintenance, Zero Mechanical State (ZMS), Definition, Policy for ZMS – guarding of hazards – point of operation protective devices, machine guarding, types, fixed guard, interlock guard, automatic guard, trip guard, electron eye, positional control guard, fixed guard fencing – guard construction – guard opening. Selection and suitability: lathe – drilling – boring – milling – grinding –shaping – sawing – shearing presses – forge hammer – flywheels – shafts – couplings – gears –sprockets wheels and chains – pulleys and belts – authorized entry to hazardous installations – benefits of good guarding systems.		
UNIT	**TITLE**	**PERIODS**
3	**SAFETY IN WELDING AND GAS CUTTING**	**9**
Gas welding and oxygen cutting, resistances welding, arc welding and cutting, common hazards, personal protective equipment, training, safety precautions in brazing, soldering and metalizing – explosive welding, selection, care and maintenance of the associated equipment and instruments – safety in generation, distribution and handling of industrial gases – colour coding – flashback arrestor – leak detection – pipe line safety – storage and handling of gas cylinders.		
UNIT	**TITLE**	**PERIODS**
4	**SAFETY IN COLD FORMING AND HOT WORKING OF METALS**	**9**
Cold working, power presses, point of operation safe guarding, auxiliary mechanisms, feeding and cutting mechanism, hand or foot – operated presses, power press electric controls, power press set up and die		

removal, inspection and maintenance – metal sheers – press brakes.		
UNIT	**TITLE**	**PERIODS**
5	**SAFETY IN FINISHING, INSPECTION AND TESTING**	**9**
Heat treatment operations, electro plating, paint shops, sand and shot blasting, safety in inspection and testing, dynamic balancing, hydro testing, valves, boiler drums and headers, pressure vessels, air leak test, steam testing, safety in radiography, personal monitoring devices, radiation hazards, engineering and administrative controls, Indian Boilers Regulation.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Implement safety rules, standards and codes in manufacturing engineering
CO2:	Select an appropriate machine guarding techniques for rotating machinery
CO3:	Adopt safety procedures in metal joining industry
CO4:	Summarize the safety concepts of cold and hot working of metals
CO5:	Articulate finishing and post manufacturing safety techniques as per standards

TEXT BOOKS:	
1.	John V. Grimaldi and Rollin H. Simonds “Safety Management “by All India Travelers Book seller, New Delhi, 1989.

REFERENCE BOOKS:	
1.	Charles D. Reese, Occupational Health and Safety Management, CRC Press, 2003
2.	Health and Safety in welding and Allied processes, welding Institute, UK, High Tech. Publishing Ltd., London, 1989.
3.	Philip E. Hagan, John Franklin Montgomery, James T. O'Reilly, Accident Prevention Manual – NSC, Chicago, 2009.
4.	Safety in Industry” N.V. Krishnan Jaico Publishery House, 1996.
5.	Singh, U.K and Dewan, J.M., Safety, Security And Risk Management, APH publishing company, New Delhi, 1996.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE063T	**COMBUSTION ENGINEERING**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To understand the fundamental of combustion phenomena in general, different combustion process, its thermodynamics and kinetics
2.	To get knowledge on combustion mechanism in different types of combustion and burner design for efficient combustion
3.	To learn different combustion models
4.	To understand the concept of laminar and turbulent flame propagation
5.	To study the effect of quantity & quality of fuel and engine technology on exhaust emissions

UNIT	TITLE	PERIODS
1	**FUELS**	**9**
Detailed classification – Conventional and Unconventional Solid, Liquid, gaseous fuels and nuclear fuels – Origin of Coal – Analysis of coal. Coal – Carborisation, Gasification and liquification – Lignite: petroleum-based fuels – problems associated with very low calorific value gases: Coal Gas – Blast Furnace Gas Alcohols and Biogas.		
UNIT	**TITLE**	**PERIODS**
2	**PRINCIPLES OF COMBUSTION**	**9**
Chemical composition – Flue gas analysis – dew point of products – Combustion stoichiometry. Chemical kinetics – Rate of reaction – Reaction order – Molecularity – Zeroth, first, second and third order reactions - complex reactions – chain reactions. Theories of reaction Kinetics – General oxidation behavior of HC's.		
UNIT	**TITLE**	**PERIODS**
3	**LAMINAR AND TURBULENT FLAME**	**9**
Detonation and Deflagration waves of premixed gasses, Rankine Hygienist relation, Hygienist curve, laminar and turbulent flame propagation and structure, burning velocity of fuels – Measurement of burning velocity – factors affecting the burning velocity.		
UNIT	**TITLE**	**PERIODS**
4	**COMBUSTION SYSTEMS**	**9**
Flame Stability, Combustion of fuel, Theory of diffusion flames, droplets and sprays – Combustion systems – Pulverized fuel furnaces – fixed, Entrained and Fluidized Bed Systems.		
UNIT	**TITLE**	**PERIODS**

5	ENVIRONMENTAL CONSIDERATIONS	9
Air pollution – Effects on Environment, Human Health etc. Principal pollutants – Legislative Measures – Methods of Emission control.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Understand the concepts of combustion phenomena in energy conversion devices
CO2:	Apply the knowledge of adiabatic flame temperature in the design of combustion devices
CO3:	Identify the phenomenon of flame stabilization in laminar and turbulent flames
CO4:	Analyze the pollution formation mechanisms in combustion of solid, liquid and gaseous fuels

TEXT BOOKS:	
1.	Combustion Fundamentals by Roger A Strehlow, Mc Graw Hill
2.	Fuels and combustion by Sharma and Chander Mohan, Tata Mc Graw Hill

REFERENCE BOOKS:	
1.	Combustion Engineering and Fuel Technology by Shaha A.K., Oxford and IBH
2.	Principles of Combustion by Kanneth K. Kuo, Wiley and Sons.
3.	Fuels & Combustion by Sameer Circar, Mc. Graw Hill.
4.	An Introduction to Combustion by Stephen R. Turns, Mc. Graw Hill International Edition.
5.	Combustion Engineering by Gary L. Berman & Kenneth W. Ragland, Mc. Graw Hill International Edition.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE064T	**BIO FLUID MECHANICS**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To understand the basics of bio fluids
2.	To learn and understand the fundaments of cellular and ocular mechanics
3.	To impart the knowledge of blood vessel mechanics
4.	To know about the cardio respiratory mechanics
5.	To understand the applications of computational dynamics in medical field

UNIT	TITLE	PERIODS
1	**BIO FLUID MECHANICS**	**9**

Intrinsic fluid properties - Density, viscosity, Compressibility, Surface tension, Hydrostatics Fluid characteristics and viscosity – Displacement and velocity, Sheer stress and viscosity Bernoulli equation, Introduction to pipe flow – Reynolds number, Poiseuille‗s law, Flow Rate, Womersley number, Constitutive equations – Newtonian fluid, Non-Newtonian viscous fluid, Diameter, velocity and pressure of blood flow relationship, Resistance against flow, Viscoelasticity – Viscoelastic models, Response to Harmonic variation, Use of viscoelastic models, Bio-Viscoelastic fluids – Protoplasm, Mucus, Saliva, Synovial fluids.

UNIT	TITLE	PERIODS
2	**CELLULAR AND OCCULAR MECHANICS**	**9**

Cellular Biomechanics – Eukaryotic cell architecture, Cytoskeleton, Cell-matrix interactions, Mechanical property measurement – Atomic Force microscopy, Optical Trapping, Magnetic bead microrheometry, Micropipette aspiration, Models of cellular biomechanical behavior, Computational model of a chondrocyte in its matrix, Mechanotransduction, Techniques for mechanical stimulation of the cells, Tissue cell mechanobiology – Endothelial, smooth muscle cells, Chondrocytes, Osteoblasts, Ocular Biomechanics – Occular anatomy, Biomechanics of Glaucoma, Ocular blood flow.

UNIT	TITLE	PERIODS
3	**BLOOD RHEOLOGY AND BLOOD VESSEL MECHANICS**	**9**

Viscometry, Elements of Blood, Blood characteristics – Viscosity of blood, Einstein‗s equation, Biomechanics of red cell membrane, Apparent and relative viscosity, Blood viscosity variation, Casson"s equation, Rheology of Blood In Micro vessels – FahraeusLindquist effect and its inversion, Anatomy and physiology of blood vessels, Arterial wall as membrane – Uniaxial loading, Biaxial loading, Torsion, Hemodynamics of Large arteries – Ventricular outflow and the aorta, Pressure-flow relations and Vascular Impedance, Wave propagation and reflection.

UNIT	TITLE	PERIODS
4	**CARDIO RESPIRATORY MECHANICS AND SPACE MEDICINE**	**9**

Cardiac cycle – Pressure volume diagrams, Changes in contractility, Ventricular performance, Congestive heart failure, Pulsality index, Physics of valvular diseases, Prosthetic heart valves and replacements, Respiratory System – Alveolar ventilation-lung volumes and capacities, Mechanics of breathing, Work of breathing – Lung compliance, Airway resistance, Gas exchange and transport, Oxygen dissociation curve, Lung surfactant, Pulmonary pathologies, Space Medicine – Hypoxia, Physiology of decompressive sickness, Human response to acceleration, Thermal Stress.

UNIT	TITLE	PERIODS
5	**COMPUTATIONAL FLUID DYNAMICS**	**9**

Computational fluid dynamics – CFD Code, Problem solving with CFD, Conservation Laws of Fluid Motion and Boundary Conditions, Turbulence and its modelling, The Finite Volume Method for Diffusion Problems and Convection-Diffusion Problems, Solution Algorithms for Pressure-Velocity Coupling in steady flows, Solution of Discretized Equations, The Finite Volume Method for Unsteady flows, Implementation of Boundary Conditions Application – Multiphysics computational models for cardiac flow and virtual cardiography.

TOTAL PERIODS:	**45**

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1:	Know the basics of fluid mechanics
CO2:	Construe the intracellular and ocular mechanics
CO3:	Describe the rheology of blood and mechanics of blood vessels
CO4:	Elucidate on cardio respiratory mechanics and space medicine
CO5:	Develop mathematical models of biological systems with fluids

TEXT BOOKS:

1.	Krishnan B. Chandran, Ajit P. Yoganathan, Stanley E. Rittgers, ―Biofluid MechanicsThe human circulation‖, CRC Taylor and Francis, 2007.
2.	Y.C Fung, ―Biomechanics- Mechanical properties of living tissues‖, 2nd Edition, Springer-Verlag, 1993.
3.	Jeffery R. Davis et. Al., ―Fundamentals of Aerospace Medicine‖, Wolter Kluwer Health, Lippincott Williams and Wilkins, 2008

REFERENCE BOOKS:

1.	Jung Hee Seo, Vijay Vedula, Theodore Abraham and Rajat Mittal, ―Multiphysics computational models for cardiac flow and virtual cardiography‖, Int. J. Numer. Meth. Biomed. Engg. (2013) Published online in Wiley Online Library.
2.	Lee Waite, Jerry Fine, ―Applied Biofluid Mechanics‖, McGraw Hill, 2007.
3.	John K-J Li, ―Dynamics of Vascular System‖, World Scientific, 2004.
4.	C. Ross Ethier, Craig A Simmons, ―Introduction to Biomechanics- From Cells to Organisms‖, Cambridge Texts in Biomedical Engineering, 2007.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE065T	**SOLAR TECHNOLOGIES**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To recognize the basic physics about solar engineering, origin and related devices used to collect solar energy.
2.	To gain knowledge about the concept of various laws related to solar engineering.
3.	To outline the basic idea of solar energy collection.
4.	To understand the physics of solar cell.
5.	To learn about various energy storage methods.

UNIT	**TITLE**	**PERIODS**
1	**INTRODUCTION TO SOLAR ENERGY**	**10**
Basics of solar energy - Brief history of solar energy utilization - Various approaches of utilizing solar energy - Blackbody radiation- Relation between radiation field energy density and radiation spectrum - Planck's formula in energy unit - Maximum spectral density - Planck's formula in wavelength unit - Wien displacement law - Stefan - Boltzmann law - Photoelectric effect - Einstein's theory of photons - Einstein's derivation of the black-body formula.		
UNIT	**TITLE**	**PERIODS**
2	**SOLAR TRACKING & ATMOSPHERIC INTERACTION**	**10**
Basic parameters of the Sun - Measurement of the solar constant - The structure of the Sun – The origin of solar energy - Rotation and orbital motion of the Earth around the Sun - Solar time, sidereal time, universal standard time, local standard time - Equation of time - Intensity of sunlight on an arbitrary surface at any time - Interaction with the atmosphere - Absorption of the molecules – Air mass - Rayleigh scattering - Direct and scattered sunlight.		
UNIT	**TITLE**	**PERIODS**
3	**SOLAR CELLS**	**9**
Formation of a PN – junction - Space charge and internal field - Quasi - Fermi levels - The Shockley diode equation - Structure of a solar cell - The solar cell equation - Fill factor and maximum power - Various electron - hole-pair recombination mechanisms - Crystalline silicon solar cells - Thin film solar cells: CIGS, Cite and a – silicon - Tandem solar cells - Dye - sensitized solar cells - Organic solar cells**.**		
UNIT	**TITLE**	**PERIODS**
4	**CONCENTRATION OF SOLAR ENERGY**	**8**
Three types of imaging optics: trough or linear collectors, central receiver with heliostats, and parabolic dish concentrator with on - axis tracking- Solar thermal electricity using Stirling engine or Ranking engine - Solar photovoltaic's with concentration.		

UNIT	TITLE	PERIODS
5	**ENERGY STORAGE**	**8**
Necessity of storage for solar energy- Chemical energy storage - Thermal energy storage – Thermal Flywheels - Compressed air- Rechargeable batteries.		
Case studies: Basic research needs for solar energy utilization-Solar panels at Boston College-International Energy Agency's concentrating solar power technologies for climate change mitigation-Battery storage of Alaska island- off-grid frequency response.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Calculate basic solar parameter
CO2:	Calculate the solar radiation at various intervals of time for a particular location
CO3:	Calculate the solar cell requirement for given load and particular location and to select suitable type
CO4:	Design concentrating collectors for given solar application
CO5:	Design storage system for a given solar application

TEXT BOOKS:	
1.	Rai, G.D., Solar Energy Utilization, Khanna Publishers, N. Delhi, 2010.
2.	Streetman B.G. and S. Banerjee, Solid State Electronic Devices, Sixth Edition, Prentice Hall, 2006.
3.	Sukhatme S.P., Solar Energy, Tata McGraw Hills P Co., 3rd Edition, 2008.

REFERENCE BOOKS:	
1.	Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process, John Wiley and Sons, New York, Jui Sheng Hsieh, Solar Energy Engineering, Prentice-Hall, 2007.
2.	M. Stix, The Sun, An Introduction, Second Edition, Springer 2002.
3.	Nelson, The Physics of Solar Cells. Imperial College Press, 2003.

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE066T	**ELECTRICAL DRIVES AND ACTUATORS**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES:

COURSE OBJECTIVES:	
1.	To familiarize a relay and power semiconductor devices
2.	To get a knowledge on drive characteristics
3.	To obtain the knowledge on DC motors and drives.
4.	To obtain the knowledge on AC motors and drives.
5.	To obtain the knowledge on Stepper and Servo motor.

UNIT	**TITLE**	**PERIODS**
1	**RELAY AND POWER SEMI-CONDUCTOR DEVICES**	**9**
Study of Switching Devices – Relay and Types, Switching characteristics -BJT, SCR, TRIAC, GTO, MOSFET, IGBT and IGCT-: SCR, MOSFET and IGBT - Triggering and commutation circuit - Introduction to Driver and snubber circuits		
UNIT	**TITLE**	**PERIODS**
2	**DRIVE CHARACTERISTICS**	**9**
Electric drive – Equations governing motor load dynamics – steady state stability – multi quadrant Dynamics: acceleration, deceleration, torque, and Direction starting & stopping – Selection of motor.		
UNIT	**TITLE**	**PERIODS**
3	**DC MOTORS AND DRIVES**	**9**
DC Servomotor - Types of PMDC & BLDC motors - principle of operation- emf and torque equations - characteristics and control – Drives- H bridge - Single and Three Phases – 4 quadrant operation – Applications		
UNIT	**TITLE**	**PERIODS**
4	**AC MOTORS AND DRIVES**	**9**
Introduction – Induction motor drives – Speed control of 3-phase induction motor – Stator voltage control – Stator frequency control – Stator voltage and frequency control – Stator current control – Static rotor resistance control – Slip power recovery control.		
UNIT	**TITLE**	**PERIODS**
5	**STEPPER AND SERVO MOTOR**	**9**
Stepper Motor: Classifications- Construction and Principle of Operation – Modes of Excitation- Drive System-Logic Sequencer - Applications. Servo Mechanism – DC Servo motor-AC Servo motor – Applications.		

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Recognize the principles and working of relays, drives and motors.
CO2:	Explain the working and characteristics of various drives and motors
CO3:	Apply the solid state switching circuits to operate various types of Motors and Drivers
CO4:	Interpret the performance of Motors and Drives.
CO5:	Suggest the Motors and Drivers for given applications.

TEXT BOOKS:	
1.	Bimbhra B.S., "Power Electronics", 5th Edition, Kanna Publishers, New Delhi, 2012.
2.	Mehta V.K. & Rohit Mehta, "Principles of Electrical Machines", 2nd Edition, S.Chand& Co. Ltd., New Delhi, 2016.

REFERENCE BOOKS:	
1.	Gobal K. Dubey, "Fundamentals of Electrical Drives", 2nd Edition, Narosal Publishing House, New Delhi, 2001.
2.	Theraja B.L. &Theraja A.K., "A Text Book of Electrical Technology", 2nd Edition, S.Chand& Co. Ltd., New Delhi, 2012.
3.	Singh M.D. &Kanchandhani K.B., "Power Electronics", McGraw Hill, New Delhi, 2007

Course Code	Course Title	Periods per week				Credits
		L	T	P	R	
191MEE067T	**ENTREPRENEURSHIP DEVELOPMENT**	**3**	**0**	**0**	**0**	**3**

PREREQUISITES: NIL

COURSE OBJECTIVES:	
1.	To learn basic concepts of entrepreneurship in economic development of the country.
2.	To develop motivation in students and to impart basic entrepreneurial skills.
3.	To provide knowledge about the sources of information on promotion and problems faced by small enterprises.
4.	To gain knowledge in various sources of finance support, types of term loans, project execution techniques, taxation.
5.	To learn about government policies on promoting small enterprises, strategies used for growth of small enterprises.

UNIT	TITLE	PERIODS
1	**ENTREPRENEURSHIP**	**9**
Entrepreneur – Types of Entrepreneurs – Difference between Entrepreneur and Intrapreneur Entrepreneurship in Economic Growth, Factors Affecting Entrepreneurial Growth.		
UNIT	**TITLE**	**PERIODS**
2	**MOTIVATION**	**9**
Major Motives Influencing an Entrepreneur – Achievement Motivation Training, Self-Rating, Business Games, Thematic Apperception Test – Stress Management, Entrepreneurship Development Programs – Need, Objectives.		
UNIT	**TITLE**	**PERIODS**
3	**BUSINESS**	**9**
Small Enterprises – Definition, Classification – Characteristics, Ownership Structures – Project Formulation – Steps involved in setting up a Business – identifying, selecting a Good Business opportunity, Market Survey and Research, Techno Economic Feasibility Assessment – Preparation of Preliminary Project Reports – Project Appraisal – Sources of Information – Classification of Needs and Agencies.		
UNIT	**TITLE**	**PERIODS**
4	**FINANCING AND ACCOUNTING**	**9**
Need – Sources of Finance, Term Loans, Capital Structure, Financial Institution, and Management of working Capital, Costing, Break Even Analysis, and Taxation – Income Tax, Excise Duty – Sales Tax.		
UNIT	**TITLE**	**PERIODS**
5	**SUPPORT TO ENTREPRENEURS**	**9**
Sickness in small Business – Concept, Magnitude, Causes and Consequences, Corrective Measures - Business Incubators – Government Policy for Small Scale Enterprises – Growth Strategies in small industry – Expansion, Diversification, Joint Venture, Merger and Sub Contracting.		

Case studies: A Case Study of Big Bazaar, A Case Study Alibaba, A Case Study of Coffee Day. - A SWOT analysis.

TOTAL PERIODS:	**45**

COURSE OUTCOMES:	
Upon completion of this course, student will be able to:	
CO1:	Understand the concept of entrepreneurship and its role on economic growth for becoming an entrepreneur.
CO2:	Demonstrate various types of motivation techniques to develop an entrepreneurship.
CO3:	Prepare a project report to start SSI unit.
CO4:	Make finance and accounting calculations needed for a business unit.
CO5:	Appreciate the support to entrepreneurs by understanding the Government policies.

TEXT BOOKS:	
1.	Donald F Kuratko, “Entrepreneurship – Theory, Process and Practice”, 9th Edition, Cengage Learning, 2014.
2.	Khanka. S.S., “Entrepreneurial Development” S.Chand & Co. Ltd., Ram Nagar, New Delhi, 2013.

REFERENCE BOOKS:	
1.	EDII “Faulty and External Experts – A Hand Book for New Entrepreneurs Publishers: Entrepreneurship Development”, Institute of India, Ahmadabad, 1986.
2.	Hisrich R D, Peters M P, “Entrepreneurship” 8th Edition, Tata McGraw-Hill, 2013.
3.	Rajeev Roy, "Entrepreneurship" 2nd Edition, Oxford University Press, 2011.