NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

M. Tech. - Automobile Engineering

DEPARTMENT OF MECHANICAL ENGINEERING

SCHEME OF INSTRUCTION AND SYALLABI

Effective from 2019-20

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

VISION

- Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

- To be a global knowledge hub in mechanical engineering education, research, entrepreneurship and industry outreach services.

MISSION

- Impart quality education and training to nurture globally competitive mechanical engineers.
- Provide vital state-of-the-art research facilities to create, interpret, apply and disseminate knowledge.
- Develop linkages with world class educational institutions and R&D organizations for excellence in teaching, research and consultancy services.

DEPARTMENT OF MECHANICAL ENGINEERING

M.TECH. IN THERMAL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES (PEOS):

Program Educational Objectives (PEOs) are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve. They are consistent with the mission of the Institution and Department. Department faculty members continuously worked with stakeholders (local employers, industry and R&D advisors, and the alumni) to review the PEOs and update them periodically.

PEO1	Apply concepts of engineering to analyze automotive systems.
PEO2	Develop innovative automotive technologies to address specific needs of performance, comfort, safety and eco-friendliness.
PEO3	Apply computational tools for comprehensive understanding of the complex systems in automotive engineering.
PEO4	Communicate effectively and support constructively towards team work
PEO5	Engage in lifelong learning for career and professional growth with ethical concern for society and the environment

MAPPING OF MISSION STATEMENTS WITH PROGRAM EDUCATIONAL OBJECTIVES:

Mission Statement	PEO1	PEO2	PEO3	PEO4	PEO5
Impart quality education and training to nurture globally competitive mechanical engineers.	3	2	3	2	3
Provide vital state-of-the-art research facilities to create, interpret, apply and disseminate knowledge.	3	3	2	2	3
Develop linkages with world class educational institutions and R&D organizations for excellence in teaching, research and consultancy services.	2	2	2	2	3

1: Slightly **2: Moderately** **3: Substantially**

PROGRAM OUTCOMES:

Program Outcomes (POs) are narrower statements that describe what the students are expected to know and be able to do upon the graduation. They relate the knowledge, skills and behavior the students acquire through the program. The Program Outcomes (PO) are specific to the program and facilitate the attainment of PEOs.

PO1	Carryout independent research/investigation and development work to solve practical problems.
PO2	Write and present a substantial technical report/document.
PO3	Demonstrate a degree of mastery over automobile engineering at a level higher than the Bachelor's program.
PO4	Apply engineering knowledge, state-of-the-art tools and techniques to design and analyze automobile systems and sub-systems.
PO5	Evaluate prime movers and analyze vehicle loads for improved performance.
PO6	Engage in lifelong learning adhering to professional, ethical, legal, safety, environmental and societal aspects for career excellence.

MAPPING OF PROGRAM OUTCOMES WITH PROGRAM EDUCATIONAL OBJECTIVES:

PEO	PO1	PO2	PO3	PO4	PO5	PO6
PEO1	3	3	2	3	3	2
PEO2	3	2	2	3	2	2
PEO3	2	1	1	2	3	2
PEO4	2	2	2	2	2	3
PEO5	3	2	3	3	3	3

1: Slightly 2: Moderately 3: Substantially

CURRICULAR COMPONENTS

Category	**I Year, Sem – I**	**I Year, Sem – II**	**II Year, Sem – I**	**II Year, Sem – II**	**Total No. of credits to be earned**
Core courses	12	06	--	--	**18**
Electives	06	12	--	--	**18**
Lab Courses	04	04	--	--	**08**
Comprehensive Viva-Voce	--	--	02	--	**02**
Seminar	01	01	--	--	**02**
Dissertation	--	--	09	18	**27**
Total	**23**	**23**	**11**	**18**	**75**

M.Tech. (AUTOMOBILE ENGINEERING)

SCHEME OF INSTRUCTIONS AND EVALUATION

I Year, Semester – I

Sl. No	Course Code	Course Title	L	T	P	Cr	Cat. Code
1	ME5501	Automotive Engineering	3	0	0	3	PCC
2	ME5102	Computational Methods in Thermal Engineering	3	0	0	3	PCC
3	ME5403	Mechanical Vibrations	3	0	0	3	PCC
4	ME5104	IC Engines and Alternate Power Sources	3	0	0	3	PCC
5		Elective-1	3	0	0	3	DEC
6		Elective-2	3	0	0	3	DEC
7	ME5541	Automotive Engineering laboratory	0	1	2	2	PCC
8	ME5542	Computational Laboratory	0	1	2	2	PCC
9	ME5543	Seminar-I	0	0	3	1	PCC
		Total	**18**	**2**	**7**	**23**	

PCC – Program Core Course; DEC: Department Elective Course

I Year, Semester – II

Sl. No	Course Code	Course Title	L	T	P	Cr	Cat. Code
1	ME5551	Vehicle Body Engineering	3	0	0	3	PCC
2	ME5456	Vehicle Dynamics	3	0	0	3	PCC
3		Elective-3	3	0	0	3	DEC
4		Elective-4	3	0	0	3	DEC
5		Elective-5	3	0	0	3	DEC
6		Elective-6	3	0	0	3	DEC
7	ME5591	Automotive Systems laboratory	0	1	2	2	PCC
8	ME5592	Modeling and Analysis laboratory	0	1	2	2	PCC
9	ME5593	Seminar-II	0	0	3	1	PCC
		Total	**18**	**2**	**7**	**23**	

II Year, Semester – I

S. No.	Course Code	Course Title	Credits	Cat.Code
1	ME5548	Comprehensive Viva – Voce	2	PCC
2	ME5549	Dissertation - Part A	9	PCC
		Total	**11**	

II Year, Semester – II

S. No.	Course Code	Course Title	Credits	
1	ME5599	Dissertation - Part B	18	PCC
		Total	**18**	

List of Elective Courses (M.Tech - Automobile Engineering)

S. No	Course Code	Course Title
1	ME5511	Automotive Electronics
2	ME5122	Renewable Sources of Energy
3	ME5123	Energy Systems and Management
4	ME5321	Enterprise Resource Planning
5	ME5331	Manufacturing Management
6	ME5336	Soft Computing Techniques
7	ME5421	Analysis and Synthesis of Mechanisms
8	ME5422	Mathematical Methods in Engineering
9	ME5621	Advanced Metal Forming
10	ME5561	Noise, Vibrations & Harshness
11	ME5562	Vehicle Testing & Instrumentation
12	ME5563	Engine Management Systems
13	ME5564	Automotive Safety & Maintenance
14	ME5171	Design of Heat Transfer Equipment
15	ME5172	New Venture Creation
16	ME5571	Combustion and Emission control
17	ME5572	Alternate Fuels & Emissions
18	ME5276	Mechatronics and Robotics
19	ME5274	Fluid Power Systems
20	ME5281	Precision Manufacturing
21	ME5386	Design and Analysis of Experiments
22	ME5387	Project Management
23	ME5471	Tribological Systems Design
24	ME5472	Condition Monitoring
25	ME5483	Computer Aided Design
26	ME5377	Reliability Engineering
27	ME5771	Re-Engineering
28	ME5479	Optimization Methods for Engineering Design
29	ME5482	Finite Element Method
30	ME5686	Non Destructive Testing
31	ME5378	Industry 4.0 and IIoT

Assessment of Academic Performance for Theory Courses:

Continuous Evaluation	:	20 marks
Mid-semester Examination	:	30 marks (as per academic calendar)
End-semester Examination	:	50 marks (as per academic calendar)
Total	:	100 marks

Assessment of Academic Performance for Laboratory Courses:

Continuous Evaluation (Lab report, viva, Quiz etc)	: 25 Marks
Skill test	: 25 Marks
End Semester Examination	: 50 Marks
Total	: 100 Marks

DETAILED SYLLABUS
I- Year, I- Semester

ME5501	AUTOMOTIVE ENGINEERING	3 - 0 - 0 (3 Cr)

Prerequisites: Internal Combustion Engines

Course Outcomes:

CO1	Identify the systems and sub-systems of a typical automobile
CO2	Analyze prime movers based on their configuration
CO3	Outline the functions of cooling, lubrication and power transmission system and its components
CO4	Interpret advanced concepts in Steering, Suspension and Braking systems
CO5	Adopt recent innovations in automobile sector like wheels, tires, air conditioning and lighting.

CO-PO Mapping:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	1
CO2	2	2	3	3	3	1
CO3	2	2	3	2	2	1
CO4	2	2	3	3	1	1
CO5	2	2	3	2	1	3

Detailed Syllabus:

Introduction: Overview of the course, Examination and Evaluation patterns, History of Automobiles, Classification of Automobiles.

Power Plant: Classification, Engine Terminology, firing order, Hybrid power sources.

Lubricating system and cooling systems: Functions & properties of lubricants, methods of lubrication-splash type, pressure type, dry sump, and wet sump & mist lubrication. Oil filters, oil pumps, oil coolers. Characteristics of an effective cooling system, types of cooling system, radiator, thermostat, air cooling & water cooling.

Transmission, axles, clutches, propeller shafts and differential: Types of gear boxes, functions and types of front and rear axles, types and functions, components of the clutches, fluid couplings, design considerations of Hotchkiss drive torque tube drive, function and parts of differential and traction control.

Steering System: functions of steering mechanism, steering gear box types, wheel geometry, power steering systems.

Braking and suspension system: functions and types of brakes, operation and principle of brakes, constructional and operation of ABS, classification of brakes
Types of springs shock observers, objectives and types of suspension system, rear axles suspension, electronic control and proactive suspension system.

Wheels and tyres: Wheel quality, assembly, types of wheels, wheel rims. Construction of tyres and tyre specifications.

Air-conditioning and Lighting system in automobile: A.C System, Voltage regulator, battery and lighting system.

Readings:

1.Joseph Heitner, Automotive Mechanics, …, CBS publications
2.Srinivasan.S, Automotive Mechanics, 2nd Edition, Tata McGraw-Hill, 2003
3. Crouse and Anglin, Automotive Mechanism, 9th Edition. Tata McGraw-Hill, 2003.
4. Jack Erjavec, A Systems Approach to Automotive Technology, Cengage Learning Pub., 2009.

ME5102	COMPUTATIONAL METHODS IN THERMAL ENGINEERING	3 - 0 - 0 (3 Cr)

Pre-requisites:
Fluid Mechanics, Heat Transfer, Numerical Methods, Computer Programming

Course Outcomes:

CO1	Understand the stepwise procedure to completely solve a fluid dynamics problem using computational methods.
CO2	Derive the governing equations and understand the behavior of the equations.
CO3	Analyze the consistency, stability and convergence of various discretization schemes for parabolic, elliptic and hyperbolic partial differential equations.
CO4	Analyze variations of SIMPLE schemes for incompressible flows and variations of Flux Splitting algorithms for compressible flows.
CO5	Analyze methods of grid generation techniques and application of finite difference and finite volume methods to solve thermal problems.

CO-PO Mapping:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		2	3		
CO2	2	2	3	3		
CO3	2	2	3	3		1
CO4	2	2	3	3		1
CO5	2	2	3	3		1

Detailed Syllabus:

Introduction: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Programming fundamentals, MATLAB programming, Numerical Methods

Governing Equations Of Fluid Dynamics: Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching.

Mathematical behavior of partial differential equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations.

Basic aspects of discretization: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, Uniform and unequally spaced grid points.

Grids with appropriate transformation: General transformation of the equations, Metrics and Jacobians, The transformed governing equations of the CFD, Boundary fitted coordinate systems, Algebraic and elliptic grid generation techniques, Adaptive grids.
PARABOLIC PARTIAL DIFFERENTIAL EQUATIONS: Finite difference formulations, Explicit methods – FTCS, Richardson and DuFort-Frankel methods, Implicit methods – Laasonen, Crank-Nicolson and Beta formulation methods, Approximate factorization, Fractional step methods, Consistency analysis, Linearization.

Stability analysis: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, Artificial dissipation and dispersion.

Elliptic equations: Finite difference formulation, solution algorithms: Jacobi-iteration method, Gauss-Siedel iteration method, point- and line-successive over-relaxation methods, alternative direction implicit methods.

Hyperbolic equations: Explicit and implicit finite difference formulations, splitting methods, multi-step methods, applications to linear and nonlinear problems, linear damping, flux corrected transport, monotone and total variation diminishing schemes, tvd formulations, entropy condition, first-order and second-order tvd schemes.

Scalar representation of NAVIER-STOKES equations: Equations of fluid motion, numerical algorithms: ftcs explicit, ftbcs explicit, Dufort-Frankel explicit, Maccormack explicit and implicit, btcs and btbcs implicit algorithms, applications.

Grid generation: Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation

Finite volume method for unstructured grids: Advantages, Cell Centered and Nodal point Approaches, Solution of Generic Equation with tetra hedral Elements, 2-D Heat conduction with Triangular Elements

Numerical solution of quasi one-dimensional nozzle flow: Subsonic-Supersonic isentropic flow, Governing equations for Quasi 1-D flow, Non-dimensionalizing the equations, MacCormack technique of discretization, Stability condition, Boundary conditions, Solution for shock flows.

Readings:

1. Anderson, J.D(Jr), Computational Fluid Dynamics, McGraw-Hill Book Company, 2017.
2. Hoffman, K.A., and Chiang, S.T., Computational Fluid Dynamics, Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.
3. Chung, T.J., Computational Fluid Dynamics, 2nd Edition, Cambridge University Press, 2014.
4. Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, 3rd Edition, CRC Press, 2013.
5. Versteeg, H.K. and Malalasekara, W., An Introduction to Computational Fluid Dynamics, Pearson Education, 2010.
6. Patankar, S.V., Numerical Heat Transfer and Fluid Flow, CRC press, 2017.

ME5403	MECHANICAL VIBRATIONS	3 - 0 - 0 (3 Cr)

Pre-requisites: Nil

Course Outcomes:

CO1	Analyze the causes and effects of vibrations in mechanical systems and identify discrete and continuous systems.
CO2	Model the physical systems into schematic models and formulate the governing equations of motion.
CO3	Compute the free and forced vibration responses of multi degree of freedom systems through model analysis and interpret the results.
CO4	Analyze and design the systems involving imbalances, transmissibility, vibration isolation and absorption.
CO5	Analyze and design to control and reduce vibration effects in machinery.

CO-PO Mapping:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	2
CO2	3	2	3	2	2	1
CO3	2	2	2	2	2	1
CO4	3	2	2	3	3	2
CO5	2	2	2	2	3	2

Detailed Syllabus:

Introduction:
Causes and effects of vibration, Classification of vibrating system, Discrete and continuous systems, degrees of freedom, Identification of variables and Parameters, Linear and nonlinear systems, linearization of nonlinear systems, Physical models, Schematic models and Mathematical models.

SDF systems:
Formulation of equation of motion: Newton –Euler method, De Alembert's method, Energy method,

Free Vibration:
Undamped Free vibration response, Damped Free vibration response, Case studies on formulation and response calculation. Forced vibration response of SDF systems: Response to harmonic excitations, solution of differential equation of motion, Vector approach, Complex frequency response, Magnification factor Resonance, Rotating/reciprocating unbalances.

Dynamics of Rotors: Whirling of rotors, Computation of critical speeds, influence of bearings, Critical speeds of Multi rotor systems.

Design case studies: design case studies dealing with Transmissibility of forces and motion Trans, Vehicular suspension, Analysis of Vehicles as single degree of freedom systems - vibration transmitted due to unevenness of the roads, preliminary design of automobile suspension. Design of machine foundations and isolators.

Two degree of freedom systems:
Introduction, Formulation of equation of motion: Equilibrium method, Lagrangian method, Case studies on formulation of equations of motion, Free vibration response, Eigen values and Eigen vectors, Normal modes and mode superposition, Coordinate coupling, decoupling of equations of motion, Natural coordinates, Response to initial conditions, coupled pendulum, free vibration response case studies, Forced vibration response, Automobile as a two degree of freedom system –bouncing and pitching modes undamped vibration absorbers, Case studies on identification of system parameters and design of undamped vibration absorbers. Analysis and design of damped vibration absorbers.

Multi degree of freedom systems:
Introduction, Formulation of equations of motion, Free vibration response, Natural modes and mode shapes, Orthogonally of model vectors, normalization of model vectors, Decoupling of modes, model analysis, mode superposition technique, Free vibration response through model analysis, Forced vibration analysis through model analysis, Model damping, Rayleigh's damping, Introduction to experimental model analysis.

Continuous systems:
Introduction to continuous systems,discretevs continuous systems. Exact and approximate solutions, free vibrations of bars and shafts, Free vibrations of beams, Forced vibrations of continuous systems Case studies, Approximate methods for continuous systems and introduction to Finite element method.

Vibration Control in structures: Introduction, , State space representation of equations of motion, Passive control, active control and semi active control o, Free layer and constrained damping layers, Piezo electric sensors and actuators for active control, semi active control of automotive suspension systems.

Reading:

1. L. Meirovich, Elements of Vibration analysis, 2nd Ed. Tata Mc-Grawhill 2007

Reference Books:

1. Singiresu S Rao, Mechanical Vibrations. 4th Ed. , Pearson education 2011
2. W.T., Thompson, Theory of Vibration,. CBS Publishers
3. Clarence W. de Silva , Vibration: Fundamentals and Practice, CRC Press LLC, 2000

ME5104	IC ENGINES AND ALTERNATE POWER SOURCES	3 - 0 - 0 (3 Cr)

Prerequisites: Internal Combustion Engines
Course Outcomes:

CO1	Understand the importance of IC engine as a prime mover and compare its performance on the basis of thermodynamic cycles and combustion process.
CO2	Identify harmful IC engine emissions and use viable alternate fuels in engines.
CO3	Analyze and evaluate engine performance and adopt improvement devices and new combustion concepts.
CO4	Classify and analyze alternate power sources for automobiles.

CO – PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1		2	3	2		2
CO2	3	2	3	2		3
CO3	2	3	3	3	3	2
CO4	2	2	3	2	3	3

Detailed Syllabus:

Introduction to IC engines: Overview of the course, Examination and Evaluation patterns-Classification of Prime Movers; IC Engines as Prime Movers; Historical Perspective-Contribution of IC Engines for Global Warming. Concept of charge, Differences between EC Engines and IC Engines-Classification, Mechanical cycle and Thermodynamic cycle, Air standard cycles-Diesel, Otto, Dual and Miller cycles. Classification of 2-s cycle engines based on scavenging, Differences between 2-s and 4-s cycle engines, Differences between SI and CI engines.

Spark Ignition Engines: Flame Propagation- Combustion phenomena (Normal and Abnormal), Factors affecting, Detonation, Ignition quality, HUCR-Carburetion and fuel injection systems for SI Engines

Compression Ignition Engines: Advantages of CI engines-Importance of air motion and Compression Ratio, Mixture Preparation inside the CC. Normal and abnormal combustion - Ignition Quality-Cetane number-Characteristics of a Good Combustion Chamber-Classification of Combustion Chambers (DI and IDI).Description of Fuel injection Systems - Individual, Unit and Common Rail (CRDI), Fuel Injectors-Nozzle types, Electronic Control Unit(ECU)-Numerical problems on fuel injection

Supercharging of IC Engines: Need of Supercharging and advantages, Configurations of Supercharging-Numerical problems on turbocharging.

Pollutant emissions from IC Engines: Introduction to clean air, Pollutants from SI and CI Engines: Carbon monoxide, UBHCs, Oxides of nitrogen (NO-NO_X) and Particulate Matter. Mechanism of formation of pollutants, Factors affecting pollutant formation. Measurement of engine emissions-instrumentation, Pollution Control Strategies, Emission norms-EURO and Bharat stage norms.

Performance of IC Engines: Classification of engine performance parameters-Measurement of brake power, indicated power and friction power. Factors affecting performance, Heat loss, Air-fuel ratio, Pumping loss, Energy Balance: Pi and Sankey diagrams Numerical problems.

Alternate Fuels: Need for Alternate fuels, Desirable Characteristics of good Alternate Fuel-Liquid and Gaseous fuels for SI and CI Engines, Kerosene, LPG, Alcohols, Bio-fuels, Natural gas, Hydrogen and use of these fuels in engines.

Batteries: Battery: lead-acid battery, cell discharge and charge operation, construction, advantages of lead- acid battery- Battery parameters: battery capacity, discharge rate, state of charge, state of discharge, depth of discharge, Technical characteristics-Ragone plots.

Electric vehicles: Introduction: Limitations of IC Engines as prime mover, History of EVs, EV system, components of EV-DC and AC electric machines: Introduction and basic structure-Electric vehicle drive train-advantages and limitations, Permanent magnet and switched reluctance motors-EV motor sizing: Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradeability

Hybrid vehicle: Configurations of hybrids, advantages and limitations-Hybrid drive trains, sizing of components Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradeability-Hydrogen: Production-Hydrogen storage systems-reformers

Fuel Cell vehicles: Fuel cells: Introduction-Fuel cell characteristics, Thermodynamics of fuel cells-Fuel cell types: emphasis on PEM fuel cell

Readings:

1. J.B. Heywood *Internal Combustion Engine Fundamentals*, McGraw Hill Co.1988
2. W.W.Pulkrabek*Engineering Fundamentals of IC Engine*, PHI Pvt.Ltd 2002
3. SethLeitman and Bob Brant *Build your own electric vehicle* McGraw Hill Co.2009.
4. F.Barbir*PEM Fuel Cells-Theory and Practice* Elsevier Academic Press-2005.
5. V.Ganeshan, *IC Engines (4th Edition)*, TMH
6. H.N.Gupta, *Fundamentals of IC Engines (2nd Edition)*, PHI

ME5541	AUTOMOTIVE ENGINES LABORATORY	0-1-2 (2 Cr)

Prerequisites: Nil

Course Outcomes:

CO1	Identify the systems and sub-systems of IC engines
CO2	Determine properties of a given fuel/oil sample and identify fuel/oil for specific use
CO3	Analyze the performance and emissions of SI and CI Engines by experimentation
CO4	Evaluate performance of compressors and steam turbine

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	2	2	2
CO2	2	3	3	2	2	2
CO3	3	3	3	2	3	2
CO4	3	3	3	2	2	2

Detailed Syllabus:

S. No	Exercise
1	Performance Test on a Single Cylinder Diesel Engine with DC shunt Dynamometer
2	Performance Test on Dual Fuel Engine with Electrical heater plugs
3	Performance Test on Single Cylinder petrol Engine with Electrical Dynamometer
4	Retardation test on a Single Cylinder Diesel Engine with DC shunt Dynamometer
5	Morse test on a Multi Cylinder Petrol Engine
6	Heat Balance Test on a Single Cylinder Diesel Engine with Water brake Dynamometer
7	Performance test on reciprocating air compressor.
8	Nozzle Test and Performance test on Prototype steam turbine
9	Determination of Fuel properties with the apparatus available in the Laboratory
10	Conduct of experiment on Computerized single cylinder diesel engine to determine performance, Heat balance, Exhaust emissions and temperatures
11	Disassembly and assembly of IC engine

ME5542	COMPUTATIONAL LABORATORY	0-1-2 (2 Cr)

Course Outcomes:

CO1	Develop codes for solution of algebraic and differential equations
CO2	Improve skills to implement CFD methods with the developed codes
CO3	Analyze real life engineering applications with the help of CFD

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3		1
CO2	2	2	3	3		2
CO3	2	3	3	3		2

Syllabus:

Writing programs using C++ and MATLAB for Solution of transcendental equations, solution of simultaneous algebraic equations, numerical differentiation and integration, solution of ordinary differential equations, Explicit and implicit methods of solving the fluid flow problems under various types of boundary conditions, methods of solving partial differential equations of elliptic, parabolic and hyperbolic types.

1. Solution of Quadratic Equations
2. Matrix Operations
3. Solution of Simultaneous Algebraic Linear Equations (Gauss-Siedel Method)
4. Solution of 1-D parabolic equations
   (a) Explicit (FTCS, DuFort-Frankel)
   (b) Implicit (Laasonen)
   Examples: (i) Fin problem with insulated and Convective end [$k A T_{xx} = h P (T-T_a)$]
   (ii) Couette Problem with and without pressure Gradient [$u_t = - p_x /\rho + \nu u_{xx}$]
5. Solution of Elliptic Equations ($T_t = \alpha T_{xx}$]
   (a) With Point Gauss Siedel method
   (b) With Point Successive Over Relaxation Method
   Examples: (i) Temperature Distribution over a rectangular plate with different Boundary conditions on the sides.
6. Solution of Linear Hyperbolic Equations. [$u_t = -a u_x$]
   (a) Using upwind and Lax explicit methods
   (b) Using BTCS and Crank-Nicolson implicit methods
   Examples: Wave propagation at a high altitude
7. Solution of Non-Linear Hyperbolic Equations. [$u_t = -u u_x$]
   (a) Lax Method
   (b) MacCormack Method
   Examples: Shock Tube Problem
8. Solution of Incompressible NSEs
   (a) Vorticity-Stream function formulation
   (b) Primitive Variable Formulation
   Examples: (i) Lid Driven Cavity Problem
   (ii) Mass entering and leaving a square chamber

Readings:

1. Versteeg, H. K. and Malalasekera, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd Edition, Pearson, 2010.
2. Tannehill, J. C., Anderson, D. A. and Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer, McGraw Hill, 2002.
3. Blazek, J., Computational Fluid Dynamics: Principles and Applications, 2nd Edition, Elsevier Science & Technology, 2006.
4. Chung, T. J., Computational Fluid Dynamics, Cambridge University Press, 2003.

ME5543	SEMINAR-I	0-0-3 (1 Cr)

CO1	Identify and compare technical and practical issues related to the area of course specialization.
CO2	Outline annotated bibliography of research demonstrating scholarly skills.
CO3	Prepare a well-organized report employing elements of technical writing and critical thinking
CO4	Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

CO-PO Mapping:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2			3
CO2	3	2	2			3
CO3	3	3	2			3
CO4	3	3	2			3

Evaluation Scheme:

Task	Description	Weightage
I	Clarity on the topic	10
II	Literature survey	30
III	Content	30
IV	Presentation	20
V	Response to Questions	10
TOTAL		**100**

Task-CO mapping:

Task/CO	CO1	CO2	CO3	CO4
I	X			
II		X		
III			X	
IV				X
V				X

I-Year, II Semester

ME5551	VEHICLE BODY ENGINEERING	3 - 0 - 0 (3 Cr)

Prerequisites: Nil

Course outcomes:

CO1	Classify vehicle body according to body shape and frame structures.
CO2	Enumerate the aerodynamic forces acting on the vehicle body and examine the methods to reduce them.
CO3	Apply the principles of simple structural surface method to strengthen vehicle body panels.
CO4	Examine the vehicle crash testing methods
CO5	Identify sources of noise and methods to minimize it.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	2	3	2	2
CO2	1	2	2	3	2	1
CO3	2	1	3	3	3	2
CO4	3	1	3	3	2	3
CO5	2	1	3	3	1	2

Detailed Syllabus

Frame: Introduction, Loads on the Frames, Construction and Cross sections of the frame, Types of Frames

Automotive Body: Vehicle body styles, Aerodynamic considerations in body profiling: Drag reduction, Drag force calculation.

Vehicle Structure: Basic requirement of stiffness and strengthVehicle structure types Demonstration of Simple Structural Surfaces (SSS).

Body Components: Bumpers, Grilles, Sill covers and side airdams, outer moldingsWeather strips, Glass and Mirrors.

Body Interiors: Seat Belt Restraint system-Air-Bag, components of Air- Bag, Dash Board

Vehicle Safety: Introduction, Crash testing, protection of occupantsTesting for occupants safety, safety controls.

Noise: Interior noise-Engine noise, Road noise, wind noise, brake noise, Interior noise: Assessment and control

TEXT BOOKS:

1. Powloski J, Vehicle Body Engineering, Business Books Ltd, 2000.
2. Lorenzo Morello, Automotive Body, Volume-I (component design), Springer, 2011
3. David A Crolla, Automotive Engineering (Power Train, Chassis system and Vehicle Body), Elsevier collection, 2009.

REFERENCE BOOKS:

1. Giles G.J. Body Construction & Design Illiffe Books Butter worth & co., 2000.
2. John Fenton Vehicle Body Layout and Analysis, Mechanical Engineering Publication Ltd., London, 2001.

ME5456	VEHICLE DYNAMICS	3 - 0 - 0 (3 Cr)

Prerequisites: Nil

Course Outcomes:

CO1	Understand the principles underlying the development and design of road vehicles under the influence of dynamic loads.
CO2	Analyze the performance and establish the design specifications for the acceleration and braking conditions.
CO3	Model, simulate and analyze the conventional road vehicles for better ride comfort.
CO4	Analyze the cornering forces and effects of tractive forces on cornering
CO5	Design suspension systems for better damping and comfort

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2	2	2	1
CO2	2	2	3	2	3	2
CO3	2		3	3	2	2
CO4	2	2	3	3	3	2
CO5	3		3	3	3	2

Detailed Syllabus:

Introduction: Hypothetical vehicle control loop, Fundamental Approach, Vehicle co-ordinates, motion variables. Forces – Dynamic axle loads, Static loads on level ground, aerodynamic forces on body, hitch forces, tire construction, size and load rating, terminology, mechanics of force generation – problems

Road Loads: Aerodynamic, Mechanics of pressure distribution – Aerodynamic forces: lift & drag, Spoilers, Lift force, side force and roll, pitch and yaw moments, Crosswind sensitivity. Rolling Resistance, Factors affecting pressure, velocity, slip temperature, etc – Total road loads – Fuel Economy Effects.

Acceleration & Braking Performance – Power limited acceleration, Static loads on level ground, aerodynamic forces on body, Fundamental Expressions, Constant retardation, Wind Resistance, Power, Braking forces, Brakes: disc and drum, front, rear and four wheel braking, Road friction rolling resistance, problems.

Vehicle Vibration and Ride characteristics: Excitation sources – road roughness, wheel assembly, driveline excitation, engine transmission. Wheel Hop Resonance. Rigid body bounce, pitch motion. Effect of vibration on vehicle riding. Influence of pressure in tyre, alignment toe in and toe out, tire wear and tire life.

Steady–State Cornering: Introduction, Low and high speed turning –Tire cornering forces, governing expressions, under steer gradient, over steer and neutral conditions. Characteristic speed, critical speed, yaw velocity gain, sideslip angle, static margin. Suspension effects on cornering

Suspension – Solid axes – Independent suspension, Trail arm, Front – Trailing rear suspension – Anti-squat and anti- pitch suspension geometry, roll center analysis, Active

suspension, suspension load – vehicle loading, load due to gyroscopic force on suspension, total load on suspension.

Reading:

1. Hans B Pacejka, Tire and Vehicle Dynamics,3rd Edition, Elsevier Ltd., 2012.
2. Amitosh D, Vehicle Dynamics, Galgotia Book Ltd., 2010.
3. Rao V Dukkipati, Road Vehicle Dynamics,Springer 2008
4. Werner and Karl, Ground Vehicle Dynamics,Springer Berlin Heidelberg, 2008.
5. Wong H, Theory of Ground Vehicles, McGraw Hill, Second edition, 2006.

ME5591	AUTOMOTIVE SYSTEMS LABORATORY	0- 1 - 2 (2 Cr)

Prerequisites: I C Engines Lab.

Course Outcomes:

CO1	Illustrate the functioning of power steering, braking and transmission systems
CO2	Perform tests on chassis dynamometer
CO3	Perform tests on wheel alignment and onboard diagnostic
CO4	Evaluate the performance characteristics of solar and fuel cell systems

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3		2	2
CO2	3	3	3	3	3	2
CO3	3	3	3	3	3	2
CO4	3	3	3	2	2	2

Detailed Syllabus:

S. No	Exercise
1	Assemble and Dismantle the Old vehicle to study the parts.
2	Study of Power steering system, Braking System, Gear Box and Clutch assembly
3	Draw the Valve Timing Diagram of a given Engine
4	Wheel alignment test
5	Onboard diagnostic test
6	Vehicle performance test using chassis dynamometer
7	Wind resistance test
8	Fuel consumption test
9	Vehicle emission measurement using chassis dynamometer as per Indian Driving Cycle (IDC)
10	Study of vehicle lighting system and bendix drive
11	V-I characteristics of solar simulator in different configurations
12	Performance test on PEM fuel cell

ME5592	MODELING AND ANALYSIS LABORATORY	0- 1 - 2 (2 Cr)

Prerequisites: Nil

Course Outcomes:

CO1	Develop code to solve structural analysis problems involving Trusses, Beams and Frames
CO2	Solve problems involving Triangular element and higher order elements using the developed code.
CO3	Solve structural problems and perform crash analysis using commercial software
CO4	Execute a medium size project.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	2
CO2	3	3	2	3	3	2
CO3	3	3	2	3	3	2
CO4	3	3	2	3	3	2

Detailed Syllabus:

S. No.	Exercise
1	Introduction to developing code for finite element analysis in MATLAB
2	Practice session on handling assembly, boundary conditions etc
3	Solving problems of Trusses
4	Solving problems of Beams and Frames
5	Solving problems involving triangular element etc
6	More practice with case studies
7	Introduction to commercial software, Ansys
8	Solving problems of Trusses using Ansys
9	Solving problems of Beams and Frames using Ansys
10	Solving problems involving triangular element etc using Ansys
11	Crash analysis using LS Dyna
12	Case studies and working on projects
13	Case studies and working on projects.
14	Case studies and working on projects.

ME5593	SEMINAR-II	0- 0 - 3 (1 Cr)

Course Outcomes:

CO1	Identify and compare technical and practical issues related to the area of course specialization.
CO2	Outline annotated bibliography of research demonstrating scholarly skills.
CO3	Prepare a well-organized report employing elements of technical writing and critical thinking
CO4	Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

CO-PO Mapping:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2			3
CO2	3	2	2			3
CO3	3	3	2			3
CO4	3	3	2			3

Evaluation Scheme:

Task	Description	Weightage
I	Clarity on the topic	10
II	Literature survey	30
III	Content	30
IV	Presentation	20
V	Response to Questions	10
TOTAL		**100**

Task-CO Mapping:

Task/CO	CO1	CO2	CO3	CO4
I	X			
II		X		
III			X	
IV				X
V				X

II-YEAR I-SEMESTER (Program Core Courses)

ME5548	COMPREHENSIVE VIVA – VOCE	2 Cr

Pre-Requisites: Nil

Course Outcomes:

CO1	Comprehend the knowledge gained in the course work
CO2	Infer principles of working of automotive systems.
CO3	Acquaint with Automobile Technology and ability in problem solving.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	2		3
CO2	3		3	3	2	3
CO3	3		3	3	3	3

ME5549	Dissertation: Part-A	(9 Cr)

Course Outcomes:

CO1	Identify a topic in advanced areas of Automobile Engineering through review of literature.
CO2	Identify gaps to formulate objectives & scope of the work.
CO3	Develop research methodology to meet the objectives.
CO4	Develop a model, experimental set-up and / or computational techniques necessary to meet the objectives.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	1		3
CO2	3	2	3	1		3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3

M.Tech Dissertation Rubric Analysis:

Task	Description
I	Selection of Topic
II	Literature Survey
III	Defining the Objectives and Solution Methodology
IV	Performance of the Task
V	Dissertation Preparation
VI	Review (Presentation & Understanding)
VII	Viva-Voce
VIII	Publications /Possibility of publication

	ME 5549			
Task (% Weightage)	**CO1**	**CO2**	**CO3**	**CO4**
I (10)	X			
II (20)	X	X		
III (30)			X	
IV (40)				X

II-YEAR II-SEMESTER (Program Core Courses)

ME5599	DISSERTATION PART – B		18 CR

Course Outcomes:

CO1	Identify methods and materials to carry out experiments/develop code.
CO2	Reorganize the procedures with a concern for society, environment and ethics.
CO3	Analyze and discuss the results to draw valid conclusions.
CO4	Prepare a report as per the recommended format and defend the work.
CO5	Explore the possibility of publishing papers in peer reviewed journals/conference Proceedings.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		3	3	2	3
CO2	2		3	3	2	3
CO3	3		3	3	2	3
CO4	3	3	3	3	3	3
CO5	3	3	3			3

M.Tech Dissertation Rubric Analysis:

Task	Description
I	Selection of Topic
II	Literature Survey
III	Defining the Objectives and Solution Methodology
IV	Performance of the Task
V	Dissertation Preparation
VI	Review (Presentation & Understanding)
VII	Viva-Voce
VIII	Publications /Possibility of publication

	ME 5599				
Task (% Weightage)	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
IV (40)	X	X			
V (20)				X	
VI (10)			X		
VII (20)				X	
VIII (10)					X

Department Elective Courses

ME5511	AUTOMOTIVE ELECTRONICS	3 - 0 - 0 (3 Cr)

Prerequisites: Nil

Course Outcomes:

CO1	Understand the need of safety and use of electronics in automobiles
CO2	Understand the electronic circuit fundamentals and basic test equipment.
CO3	Analyze vehicle electronic circuits.
CO4	Outline the working of batteries, starting systems, charging systems, ignition systems and auxiliaries.
CO5	Understand the working of sensors and ECU.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	2	3
CO2	1	1	1	2	1	1
CO3	2	1	3	3	2	2
CO4	1	1	2	2	1	1
CO5	1	1	2	2	1	1

Detailed Syllabus:

Introduction: Overview of the course, Examination and Evaluation patterns, History of Automotive electronics.

Safety and Communication: Safe working practices-work cloths, eye protection, fire protection, battery safety. Working as an electricity / electronics technician-your toolbox, access to wiring diagrams and repairs information, communicating with the customer, working around air bags

Circuit fundamentals and basic test equipment: voltage, current**,** resistance, circuits components, series and parallel circuits, purpose of voltmeters, measuring voltage drop, connecting the voltmeter, types of ammeters, current probes, reading and interpreting ohmmeter readings, continuity testing.

Vehicle circuits: circuit components, analyzing series and parallel circuits, control circuits, diagnosing open and short circuits.

Digital Storage Oscilloscope: voltage and time setting, DSO trigger and slope, using a current probe with DSO, using the DSO's multiple-trace capability.

Electronic fundamentals: solid state devices, electronic control input devices, diagnosing and servicing electronic control input devices, integrated circuits as input devices, diagnosing and servicing ICs, oxygen sensors, diagnosing and servicing oxygen sensors.

Wiring diagrams and Batteries: wiring diagram symbols, using the wiring diagram as aservice tool, automotive batteries, diagnosing batteries, servicing batteries.

Starting and charging systems: starting circuits, solenoid shift starters, diagnosing and servicing solenoid shift starters systems, positive engagement starters, diagnosing and servicing positive engagement starting system, gear-reduction starters, diagnosing gear-reduction starters, charging system overview, field circuits, diagnosing and servicing the charging system.

Ignition systems and accessories: secondary ignition systems, servicing the secondary ignition system, primary ignition system, diagnosing and servicing distributed primary ignition systems, distributorless ignition secondary circuits, diagnosing and servicing the secondary ignition system on a distributorless vehicles, distributorless ignition primary circuits, diagnosing and servicing the primary circuit on a distributorless ignition system. Lighting circuits, diagnosing lighting circuits, defogger, horn, and windshield wiper circuits, diagnosing defogger, horn, and windshield wiper circuits, motor driven accessories, diagnosing motor driven accessories.

Cooling of Electronics Equipment: Cooling load of electronics equipment, thermal environment, Electronics cooling in automotive systems, air cooling, liquid cooling, immersion cooling.

Electronic control units and sensors: Vehicle sensors-speed, temperature, fuel level, battery condition, emissions, feedback circuits.

Reading :

1. Al Santini, Automotive Technology, Electricity and Electronics, Cengage Publishers, 2011.
2. William Ribbens, Understanding Automotive Electronics, 6th Edition, Elsevier, 2011.

ME5122	RENEWABLE SOURCES OF ENERGY	3 - 0 - 0 (3 Cr)

Pre - Requisites: Nil

Course Outcomes:

CO1	Identify the renewable energy sources and their utilization
CO2	Understand the basic concepts of the solar radiation and analyze the solar thermal systems for their utilization
CO3	Understand the principle of working of solar cells and their modern manufacturing techniques
CO4	Analyze wind energy conversion systems and their applications
CO5	Design of solar thermal and energy storage systems for specific applications
CO6	Evaluate the energy conversion from ocean thermal energy, geothermal energy, biomass and magneto hydrodynamic power generation

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	2		1
CO2	2	2	2	2		2
CO3	2	2	2	2		2
CO4	2	2	2	1		2
CO5	3	3	2	2		3
CO6	2	2	2	1		2

Detailed Syllabus:

Introduction: Overview of the course, Examination and Evaluation patterns. Classification of energy resources, energy scenario in the world and India.

Basic sun-earth relationships: Definitions. Celestial sphere, altitude-azimuth, declination-hour angle and declination-right ascension coordinate systems for finding the position of the sun, celestial triangle and coordinates of the sun. Greenwich Mean Time, Indian Standard Time, Local Solar Time, sun rise and sun set times & day length.

Solar radiation: Nature of solar radiation, solar radiation spectrum, solar constant, extra-terrestrial radiation on a horizontal surface, attenuation of solar radiation, beam, diffuse and global radiation. Measurement of global, diffuse and beam radiation. Prediction of solar radiation; Angstrom model, Page model, Hottel's model, Liu and Jordan model etc. Insolation on an inclined surface, angle of incidence.

Solar thermal systems: Principle of working of solar water heating systems, solar cookers, solar desalination systems, solar ponds, solar chimney power plant, central power tower power plants etc. Classification of solar concentrators, Basic definitions such as concentration ratio, angle of acceptance etc., Tracking of the sun; description of different tracking modes of a solar collectors and the determination of angle of incidence of insolation in different tracking modes.

Photovoltaic energy conversion: Introduction. Single crystal silicon solar cell, i-v characteristics, effect of insolation and temperature on the performance of silicon cells. Different types of solar cells. Modern technological methods of producing these cells. Indian and world photovoltaic energy scenario.

Energy storage: Necessity for energy storage. Classification of methods of energy storage. Thermal energy storage; sensible heat storage, latent heat storage. Reversible chemical reaction storage. Electromagnetic energy storage. Hydrogen energy storage. Chemical battery storage. Pumped hydel energy storage etc.

Wind energy : Origin of winds, nature of winds, wind data measurement, wind turbine types and their construction, wind-diesel hybrid system, environmental aspects, wind energy programme in India and the world.

Fuel cells: Introduction, applications, classification, different types of fuel cells such as phosphoric acid fuel cell, alkaline fuel cell, PEM fuel cell, MC fuel cell. Development and performance fuel cells.

Ocean energy : Ocean thermal energy; open cycle & closed cycle OTEC plants, environmental impacts, challenges, present status of OTEC systems. Ocean tidal energy; single basin and double basin plants, their relative merits. Ocean wave energy; basics of ocean waves, different wave energy conversion devices, relative merits.

Biomass: Introduction, photosynthesis, biofuels, biomass resources, biomass conversion technologies, urban waste to energy conversion, biomass to ethanol conversion, biomass energy scenario in India, biogas production, constant pressure and constant volume biogas plants, operational parameters of the biogas plant

Geothermal energy: Origin, applications, types of geothermal resources, relative merits
Magneto hydrodynamic Power Generation applications; Origin and their types; Working principles.

Magneto hydrodynamic Power Generation: Magneto hydrodynamic Power Generation applications; Origin and their types; Working principles.

Readings:

1. B.H.Khan, Non conventional Energy Resources, Tata McGraw Hill, New Delhi, 2012
2. S.Rao and B.B.Parulekar, Energy Technology: Non-Conventional, Renewable and Conventional, Khanna Publishers, 2010
3. S.P.Sukhatme and J.K.Nayak, Solar Energy-Principles of Thermal Collection and Storage, TMH, 2008
4. J.A.Duffie and W.A.Beckman, Solar Energy Thermal Processes, John Wiley, 2010

ME5123	ENERGY SYSTEMS AND MANAGEMENT	3 - 0 - 0 (3 Cr)

Prerequisites: Nil

Course Outcomes:

CO1	Understand the fundamentals of energy management
CO2	Select methods of energy production for improved utilization.
CO3	Apply the principles of thermal engineering and energy management to improve the performance of thermal systems.
CO4	Analyze the methods of energy conservation and energy efficiency for buildings, air conditioning, heat recovery and thermal energy storage systems.
CO5	Evaluate energy projects on the basis of economic and financial criteria.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1	2	2
CO2	2	1	3	3	2
CO3	2	1	3	3	2
CO4	2	1	3	3	1
CO5	2	1	3	3	2

Detailed Syllabus:

Introduction: Review of the concepts of Thermodynamics, Fluid Mechanics and Heat Transfer, Properties of Heat transfer media –Pure substances, Thermal fluids, Air-water vapour mixtures; Heat transfer equipment- Heat exchangers, Steam plant.

Energy storage Methods and systems: Thermal, Electrical and Mechanical energy storage methods and systems, Energy saving.

Energy conversion systems: Thermo-mechanical energy conversion systems – IC Engines, Gas Turbines and Steam turbines.

Heat recovery systems: Incinerators, regenerators and boilers.

Energy Conservation: Methods of energy conservation and energy efficiency for buildings, air conditioning, heat recovery and thermal energy storage systems.

Energy Management: Principles of Energy Management, Energy demand estimation, Organising and Managing Energy Management Programs, Energy pricing.

Energy Audit: Purpose, Methodology with respect to process Industries, Characteristic method employed in Certain Energy Intensive Industries.

Economic Analysis: Scope, Characterization of an Investment Project. **Case studies**

Readings:

1. Turner, W. C., Doty, S. and Truner, W. C., Energy Management Hand book, 7th edition, Fairmont Press, 2009.
2. De, B. K., Energy Management audit & Conservation, 2nd Edition, Vrinda Publication, 2010.
3. Murphy, W. R., Energy Management, Elsevier, 2007.
4. Smith, C. B., Energy Management Principles, Pergamon Press, 2007.

ME5321	ENTERPRISE RESOURCE PLANNING	3 - 0 - 0 (3 Cr)

Pre-Requisites: NIL

Course Outcomes:

CO1	Understand the concepts of ERP and managing risks.
CO2	Choose the technologies needed for ERP implementation.
CO3	Develop the implementation process.
CO4	Analyze the role of Consultants, Vendors and Employees.
CO5	Evaluate the role of PLM, SCM and CRM in ERP.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1			2
CO2	3	3	1	2		2
CO3	2	2	2	1		2
CO4	3	2	2			2
CO5	2	2	1	1		3

Detailed Syllabus:

Introduction to ERP: Enterprise – an overview, brief history of ERP, common ERP myths, Role of CIO, Basic concepts of ERP, Risk factors of ERP implementation, Operation and Maintenance issues, Managing risk on ERP projects.

ERP and Related Technologies: BPR, Data Warehousing, Data Mining, OLAP, PLM, SCM, CRM, GIS, Intranets, Extranets, Middleware, Computer Security, Functional Modules of ERP Software, Integration of ERP, SCM and CRM applications.

ERP Implementation: Why ERP, ERP Implementation Life Cycle, ERP Package Selection, ERP Transition Strategies, ERP Implementation Process, ERP Project Teams.

ERP Operation and Maintenance: Role of Consultants, Vendors and Employees, Successes and Failure factors of ERP implementation, Maximizing the ERP system, ERP and e-Business, Future Directions and Trends.

Readings:

1. Alexis Leon, Enterprise Resource Planning, Tata McGraw Hill, Second Edition, 2008.
2. Jagan Nathan Vaman, ERP in Practice, Tata McGraw Hill, 2007.
3. Carol A Ptak, ERP: Tools, Techniques, and Applications for Integrating the Supply Chain, 2nd Edition, CRC Press, 2003.

ME5331	MANUFACTURING MANAGEMENT	3 - 0 - 0 (3 Cr)

Pre-Requisites: Nil

Course Outcomes:

CO1	Design of production planning and control systems encompassing competitive priorities and strategies.
CO2	Evaluate and interpret Demand Forecast for production planning.
CO3	Design an optimal facility layout and select appropriate product design approach.
CO4	Apply ROP, MRP and JIT systems for inventory control in production systems.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	1	3	2
CO2	2		1	2	1	
CO3	3	2	2	2	2	1
CO4	2	1	2	3	3	1

Detailed Syllabus:

Competitive priorities and manufacturing strategy: Introduction, Historical perspective of manufacturing management, Competitive priorities and operational strategy, Functional area strategy and Capability, Case Study.

Demand Forecasting: Introduction, Quantitative Methods introduction, Time series and moving averages method, Exponential Smoothing method, Regression Analysis Method, Qualitative Methods.

Facility Design: Introduction and History, Product design and process selection, Capacity planning, Plant location and Plant layout.

Inventory control: From EOQ to ROP, Independent Demand Inventory control & Economic Order Quantity (EOQ), Dynamic lot sizing, Statistical inventory control models.

The MRP crusade: History, Need, Evolution, Dependent Demand & Material Requirement Planning (MRP), Structure of MRP system, MRP Calculations.

The JIT revolution: Just-in-Time System: origin & goals, Characteristics of JIT Systems, Continuous Improvement, The Kanban System, Strategic Implications of JIT System.

Production Planning and Control: Shop floor control, Production scheduling, Aggregate planning, Aggregate and workforce planning.

READING:

1. Krajewski U and Ritzman LP, Operations Management: Strategy and Analysis, Pearson Education Pvt Ltd., Singapore, 2002.
2. Gaither N and Frazier G, Operations Management, Thomson Asia Pvt. Ltd., Singapore, 2002.
3. Chase RB, Aquilano NJ and Jacobs RF, Operations Management for Competitive Advantage, McGraw-Hill Book Company, NY, 2001

ME5336	SOFT COMPUTING TECHNIQUES	3 - 0 - 0 (3 Cr)

PRE REQUISITES: Nil

Course Outcomes:

CO1	Classify and differentiate problem solving methods and tools.
CO2	Apply A*, AO*, Branch and Bound search techniques for problem solving.
CO3	Formulate an optimization problem to solve using evolutionary computing methods.
CO4	Design and implement GA, PSO and ACO algorithms for optimization problems in Mechanical Engineering.
CO5	Apply soft computing techniques for design, control and optimization of Manufacturing systems.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2			
CO2			2			2
CO3	1		2	1		
CO4	1	1	2	2		3
CO5	2	2	2	2		2

Detailed Syllabus:

Problem Solving Methods and Tools: Problem Space, Problem solving, State space, Algorithm's performance and complexity, Search Algorithms, Depth first search method, Breadth first search methods their comparison, A*, AO*, Branch and Bound search techniques, p type, Np complete and Np Hard problems.

Evolutionary Computing Methods: Principles of Evolutionary Processes and genetics, A history of Evolutionary computation and introduction to evolutionary algorithms, Genetic algorithms, Evolutionary strategy, Evolutionary programming, Genetic programming.

Genetic Algorithm and Genetic Programming: Basic concepts, working principle, procedures of GA, flow chart of GA, Genetic representations, (encoding) Initialization and selection, Genetic operators, Mutation, Generational Cycle, applications.

Swarm Optimization: Introduction to Swarm intelligence, Ant colony optimization (ACO), Particle swarm optimization (PSO), Artificial Bee colony algorithm (ABC), Other variants of swarm intelligence algorithms.

Advances in Soft Computing Tools: Fuzzy Logic, Theory and applications, Fuzzy Neural networks, Pattern Recognition, Differential Evolution, Data Mining Concepts, Applications of above algorithms in manufacturing engineering problems.

Artificial Neural Networks: Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Back propagation algorithm, factors affecting back propagation training, applications.

Application of Soft Computing to Mechanical Engineering/Production Engineering Problems: Application to Inventory control, Scheduling problems, Production, Distribution, Routing, Transportation, Assignment problems.

READING:

1. Tettamanzi Andrea, Tomassini and Marco, *Soft Computing Integrating Evolutionary, Neural and Fuzzy Systems*, Springer, 2001.
2. Elaine Rich, *Artificial Intelligence*, McGraw Hill, 2/e, 1990.
3. Kalyanmoy Deb, *Multi-objective Optimization using Evolutionary Algorithms*, John Wiley and Sons, 2001.

ME5421	ANALYSIS AND SYNTHESIS OF MECHANISMS	3 - 0 - 0 (3 Cr)

PRE-REQUISITES: Theory of Machines

Course Outcomes:

CO1	Understand basic mechanisms and machines and formulate the design problem.
CO2	Develop analytical equations for relative position, velocity and acceleration of all moving links.
CO3	Analyze Simple and Complex mechanisms.
CO4	Apply the knowledge of Kinematic theories to practical problems of mechanism design and synthesis.
CO5	Design higher pair kinematic linkages for a given application.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2	2	2	1
CO2	3	2	3	3	2	1
CO3	3	3	3	2	2	2
CO4	3	2	3	3	3	2
CO5	3	3	3	3	3	3

Detailed Syllabus:

INTRODUCTION: Mechanisms and machines, Planer and Spatial Mechanisms, Mobility, type of motion, links, joints and kinematic chains, of mechanisms, four bar chain, isomers, Linkage transformation, Inversion, four link planar mechanisms, Groshof condition, spring as a link, complaint mechanisms, Practical considerations – pin joints versus sliders.

POSITION ANALYSIS: Position and systems, co-orindinate transformation, rotation, translation and combined motion, Algebraic position analysis, position any point on a linkage, transmission angles, toggle positions.

KINEMATICS OF RIGID BODIES: Plane Motion of a rigid body, graphical velocity and acceleration analysis, Instantaneous centres of velocity, Centrodes, velocity of rub, Analytical solutions for velocity Analysis – velocity of any point on a linkage, Acceleration of any point on a linkage, coriolis acceleration. Analytical solutions for velocity and acceleration analysis - loop closure equations, Case studies – four-bar pin joined linkage, four link slider-crank.

ANALYTICAL LINKAGE SYNTHESIS: Types of kinematic synthesis – Motion and Path generation, Number synthesis, Dimensional synthesis, Two position synthesis for rocker output, Precision Points, Comparison of analytical and graphical two position synthesis, three position synthesis.

GRAPHICAL LINKAGE SYNTHESIS: Two position synthesis for rocker output, Three position synthesis, Position synthesis for more than three positions(four and six bar quick return), Coupler curves, Exact and approximate straight line mechanisms.

CAM: Terminology, types of follower, follower motions, cams, SVAJ diagrams, law of cam design, Single and Double dwell cam design using SHM, cycloidal displacement, combined functions. Critical path motion, practical design considerations.

GEARS AND GEAR TRAINS: Law of gearing, involute tooth form, pressure angle, backlash, contact ratio, Interference and method to avoid interference, Gear Train and its analysis.

Reading:

1. Kinematics and Dynamics of machinery, R L. Norton, Pearson , 2009
2. Kinematics Analysis and Synthesis of Mechanisms - A K Mallik, Amitabha Ghosh and Guntur, D. CRC Press, 2011.
3. Mechanical Engineering Design - Shigley et al., Tat McGraw Hill, 2011.

ME5422	MATHEMATICAL METHODS IN ENGINEERING	3 - 0 - 0 (3 Cr)

PRE-REQUISITES: Nil

Course Outcomes:

CO1	Apply methods of Applied Linear Algebra in engineering design.
CO2	Solve problems involving Nonlinear Optimization in engineering.
CO3	Simulate engineering systems using Numerical Methods.
CO4	Model the physical systems using Differential Equations.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		3	1		2
CO2	2		3	1		2
CO3	2		3	1		2
CO4	2	2	3	1		2

Detailed Syllabus:

Mathematical Modeling: Modeling of systems related to mechanical engineering, assumptions, appropriate methods and fundamental of a computer implementation

Numerical Linear Equations: Introduction, Basic Ideas of Applied Linear Algebra, Systems of Linear Equations, Square, Non-Singular Systems, the Algebraic Eigenvalue Problem, Matrix Decompositions, Computer implementation of the methods for applications in engineering analysis.

Outline of Optimization Techniques: Introduction to Optimization, Multivariate Optimization, Constrained Optimization, Optimality Criteria, Computer implementation of the methodsfor applications in design optimization, manufacturing and thermal process optimization.

Topics in Numerical Analysis: Interpolation, Regression, Numerical Integration, Numerical Solution of ODE's as IVP Boundary Value Problems. Application of numerical methods for research in mechanical engineering.
Overviews: PDE's and Variational Calculus: Separation of Variables in PDE's, Hyperbolic Equations, Parabolic and Elliptic Equations, Membrane Equation, and Calculus of Variations. Applications in mechanical engineering research.

Reading:

1. E. Kreyszig , Advanced Engineering Mathematics, Wiley, 2010.
2. B. Dasgupta , Applied Mathematical Methods, Pearson Education, 2006.
3. M. T. Heath, Scientific Computing, McGraw-Hill Education, 2001.

4. Steven Chapra, Applied Numerical Methods with Matlab, McGraw-Hill Education, 2011.

ME5621	ADVANCED METAL FORMING	3 - 0 - 0 (3 Cr)

PRE-REQUISITES: Nil
Course Outcomes:

CO1	Solve for strain rates, temperatures and metallurgical states in forming problems
CO2	Develop process maps for metal forming processes using plasticity principles.
CO3	Estimate formability limits for sheets and bulk metals.
CO4	Evaluate workability of different ductile materials
CO5	Apply FE principles to simulate metal forming processes

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	2	2
CO2	2	1	3	3	2	2
CO3	2	1	3	3	2	2
CO4	2	1	3	3	2	2
CO5	2	1	3	3	2	2

Detailed Syllabus:

Introduction Metal forming as a manufacturing process and its relation with other processes – Classification based on type of stresses - Examples.

Theoretical analysis (theory of plasticity), Stress-strain relationship, Strain hardening, Material incompressibility, Work of plastic deformation, Work hardening, Yield criteria, Flow rule, Yield criterion and flow rule for Anisotropic material, Initiation and extent of plastic flow- Problems.

Overview of various metal forming operations: Mechanics of Various Plastic Flow Problems Introduction to; (i). Theory of slip lines, Upper bound theorem, Lower bound theorem.

Forging processes: Metal flow in forging, Analysis of plane strain compression, Analysis of compression of circular disc with slab method.

Extrusion Processes: Calculation of extrusion load using slab method, slip line method and upper bound method. Defects in extrusion. Direct & indirect extrusion.

Wire Drawing Processes: Introduction, wire drawing load calculation using slab method.

Rolling Processes: Analysis of longitudinal strip or sheet rolling process (calculation of roll separating force, torque & power, angle of bite, maximum reduction in rolling), rolling defects.

Sheet forming: Mechanics – Flow Rules – Anisotropy - Formability of sheet, Formability tests, forming limit diagrams, Case studies.

Pressing and Sintering: Workability Studies – Densification - Problems & Case Studies

Incremental Forming: Statics and Kinematics of Incremental Stresses and Strains - The Kinematics of Two-Dimensional Strain, The Kinematics of Three-Dimensional Strain, Incremental Stresses in Two Dimensions, Incremental Stresses in Three Dimensions, Equilibrium Equations for the Stress Field in Two Dimensions, Equilibrium Equations for the Stress Field in Three Dimensions,

Modeling and Simulation in Metal Forming: Plasticity and Viscoelasticity – Constitutive relations - The Plane Strain Compression Test, FEM Model and Input Data to the Model - Deformations in the Compression Gap - Effective Strain and Strain-Rate Distributions in Deformed Zones - Damage Parameter and Edge Cracking.

READING:

1. Surender Kumar, *Technology of Metal Forming Processes*, Prentice - Hall, Inc., 2008.
2. Henry S. Valberg, *Applied Metal Forming - Including FEM Analysis*, Cambridge University Press, 2010.
3. Metal Forming: Mechanics and Metallurgy by William F. Hosford and Robert M. Caddell, Prentice-Hall (USA) – 2012
4. Slater.RA.C., Engineering Plasticity-Theory & Applications to Metal Forming, John Wiley and Sons, 1987.
5. Shiro Kobayashi,Altan.T, Metal Forming and Finite Element Method, Oxford University Press, 1989
6. Maurice A. Biot, Mechanics of Incremental Deformations, John Wiley & Sons,2008

ME5561	NOISE, VIBRATIONS & HARSHNESS	3- 0 - 0 (3 Cr)

Course Outcomes:

CO1	Identify sources of noise and vibration
CO2	Measure sound intensity and human sensitivity
CO3	Model statistical energy analysis and simulators
CO4	Evaluate active control techniques
CO5	Identify and evaluate the signal processing techniques.

CO-PO Mapping:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	3	2
CO2	3	3	2	3	2	2
CO3	3	2	3	2	3	2
CO4	3	3	2	2	3	2
CO5	3	2	3	3	2	2

Detailed Syllabus:

NVH in the Automotive Industry: Sources of noise and vibration. Design features. Common problems. Marque values. Noise quality. Pass-by noise requirements. Target vehicles and objective targets. Development stages in a new vehicle programme and the altering role of NVH engineers.

Sound and Vibration Theory: Sound measurement. Human sensitivity and weighting factors. Combining sound sources. Acoustical resonances. Properties of acoustic materials. Transient and steady state response of one degree of freedom system applied to vehicle systems. Transmissibility. Modes of vibration.

Test Facilities and Instrumentation: Laboratory simulation: rolling roads (dynamometers), road simulators, semi-anechoic rooms, wind tunnels, etc. Transducers, signal conditioning and recording systems. Binaural head recordings., Sound Intensity technique, Acoustic Holography, Statistical Energy Analysis.

Signal Processing: Sampling, aliasing and resolution. Statistical analysis. Frequency analysis. Campbell's plots, cascade diagrams, coherence and correlation functions.

NVH Control Strategies & Comfort: Source ranking. Noise path analysis. Modal analysis. Design of Experiments, Optimisation of dynamic characteristics. Vibration absorbers and Helmholtz resonators. Active control techniques.

Reading :

1. Norton M P, Fundamental of Noise and Vibration, Cambridge University Press,2001
2. Munjal M.L., Acoustic Ducts and Mufflers, John Wiley, 2002

Reference Books:

1. Baxa, Noise Control of Internal Combustion Engine, John Wiley, 2000.
2. Ewins D. J., Model Testing : Theory and Practice, John Wiley,1995.
3. Boris and Kornev, Dynamic Vibration Absorbers, John Wiley, 1993.
4. McConnell K, “Vibration Testing Theory and Practice”, John Wiley, 1995.

ME5562	VEHICLE TESTING AND INSTRUMENTATION	3- 0 - 0 (3 Cr)

Prerequisites: Nil

Course Outcomes:

CO1	Understand conceptual development of zero, first and second order instruments used in automobiles.
CO2	Estimate error and uncertainty with regard to instruments and equipment used in engine and vehicle testing.
CO3	Analyze sensing requirements for measurement of measurands such as load, emissions, aerodynamic forces etc.
CO4	Apply the principles of measurement for testing the engines and vehicles.

CO-PO Mapping:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	2		1
CO2	2	1	2	2		1
CO3	2	3	3	2		1
CO4	2	2	3	2		2

Detailed Syllabus:

Introduction: Overview of the course-Need of vehicle testing(engine testing both for performance and emissions in specific)-Requirement of standard instrumentation and equipment, certification and national and international standards, Importance of expertise in testing, certification.

Measurement fundamentals: Definitions associated with measurements-Least count, resolution, Precision, Accuracy, Error / Uncertainty analysis- Data collection and handling-Simple numerical problems, Measurement of errors and statistical analysis.

Instrument Characteristics: Static and dynamic characteristics, zero, first and second order systems.

Sensors and Transducers: Different types of sensors and transducers used in the automobiles, working principles.

Measurement and Testing: Engine Testing, Testing under constant speed and variable speed condition, engine dynamometers, Measurement of in-cylinder pressure, temperatures, Testing of injection systems, measurement of v**ehicle Emissions,** Emission regulations and legislation- EURO and Bharat Stage norms, Drag measuring techniques-drag reduction strategies.

Vehicle performance and testing techniques: Schematic layout of typical vehicle-Types of testing for both engine in specific, and whole vehicle body. Testing procedure for electric vehicles- -Chassis and Rolling road dynamometers-Brief introduction to testing of tires, steering, brakes, wheel alignment-Introduction to on-board diagnostics.

Vehicle certification: Need for Vehicle certification and facilities required, Importance driving cycles-Indian Driving Cycle, MIDC-procedures, Introduction to other country driving cycle-Japan, EUDC

Reading Books:

1. Heinz Heisler, Advance Vehicle Technology, Butterworth-Heinemann, 2002
2. Tom Denton, Advanced Automotive Fault Diagnosis, Elsevier Butterworth-Heinemann,2006
3. Martyr and Plint, Engine testing-theory and Practice, Butterworth-Heinemann, 2002.
4. J.P. Holman, Experimental Methods for Engineers, Tata McGraw Hill Co. 2007.

ME5563	ENGINE MANAGEMENT SYSTEMS	3- 0 - 0 (3 Cr)

Prerequisites: I C Engines

Course Outcomes:

CO1	Identify the modern automobile accessories and engine management systems.
CO2	Understand the computerized engine testing and diagnosis procedures for manufactures of engine control systems.
CO3	Understand the concept of various sensors and actuators
CO4	Classify SI and CI engine management systems
CO5	Understand the principles and application of electronic fuel and ignition management systems in the modern automobile.

CO-PO Mapping:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3		2	
CO2	3		2		2	
CO3	3	2	3	1	3	2
CO4	2		3		3	
CO5	3	2	3	1	2	

Detailed Syllabus:

Engine Input Sensors : Coolant & Intake Temperature, Crankshaft Position, Camshaft Position, Manifold Absolute Pressure, Throttle Position, Oxygen, Air/Fuel Ratio, Knock Speed & Distance, Battery & Switches

Output Devices: Relays, Injector Sequencing & Management, Ignition Operation, Idle Air Control, EGR, EVAP, Wastegate Solenoids, Torque Converter & Speed Control, Malfunction Indicator Light

Speed Density/Mass Air Flow Fuel Management Strategies: Key ON Mode, Crank Mode, Open & Closed Loop, Wide-Open Throttle, Adaptive Memory Cells, Cruise &Deceleration, Wide-Open Throttle, Key OFF Mode

Fuel Injection Systems: Electronic Fuel Systems, Computer Self-Diagnostic Circuits, Electronic Throttle Actuator Control Systems, Fuel Control, Fuel Supply System Control, Injection System Inspection and Maintenance.

Engine Diagnostic Procedures: Fuel System testing, On Board Diagnostics, Monitored & Non Monitored Circuits, Diagnostic Trouble Codes

Digital Engine Control System: Open loop and close loop control system, engine cooling and warm up control, idle speed control, acceleration and full load enrichment, deceleration fuel cutoff. Fuel control maps, open loop control of fuel injection and closed loop lambda control exhaust emission control, on-board diagnostics, diagnostics, future automotive electronic systems, Electronic dash board instruments – Onboard diagnosis system.

SI Engine Management: Feedback carburetor system, throttle body injection and multi point fuel injection system, injection system controls, advantage of electronic ignition systems, three way catalytic converter, conversion efficiency versus lambda. Layout and working of SI engine management systems like Bosch Monojetronic, L-Jetronic and LH-Jetronic. Group and sequential injection techniques. Working of the fuel system components. Advantages of electronic ignition systems. Types of solid state ignition systems and their principle of operation, Contactless electronic ignition system, Electronic spark timing control.

CI Engine Management: Fuel injection system, parameters affecting combustion, noise and emissions in CI engines. Pilot, main, advanced, post injection and retarded post injection. Electronically controlled Unit Injection system. Layout of the common rail fuel injection system. Working of components like fuel injector, fuel pump, rail pressure limiter, flow limiter, EGR valve control in electronically controlled systems.

Reading Books:

1. Halderman, J. & Linder, J. (2012). Automotive Fuel and Emissions Control Systems (3rd Edition)Upper Saddle River, NJ: Pearson Education.

2. Halderman, J. D. (2011). Diagnosis &Troubleshooting of Automotive Electrical, Electronic, &Computer Systems (6th Edition) Upper Saddle River, NJ: Pearson Education.
3. Diesel Engine Management by Robert Bosch, SAE Publications, 3rd Edition, 2004
4. Gasoline Engine Management by Robert Bosch, SAE Publications, 2nd Edition, 2004
5. Understanding Automotive Electronics – Bechfold SAE 1998
6. Automobile Electronics by Eric Chowanietz SAE.
7. Fundamentals of Automotive Electronics - V.A.W.Hilliers - Hatchin, London

Reference:

1.Automobile Electrical & Electronic Equipments (2000) Young, Griffitns - Butterworths, London.
2.Understanding Automotive Electronics, Wiliam B. Ribbens, 5th Edition, Newnes, Butterworth–Heinemann, 2001.
3. Automotive Computers & Digital Instrumentation – Robert N. Brandy, Prentice Hall, 2004
4. The Fundamentals of Electrical Systems - John Hartly - Longman Scientific & Technical, 2002.

ME5564	AUTOMOTIVE SAFETY AND MAINTENANCE	3- 0 - 0 (3 Cr)

Prerequisites: Nil

Course Outcomes:

CO1	Identify safety systems necessary for automobiles
CO2	Understand active and passive safety systems
CO3	Design and develop automobile safety systems, comfort and convenience systems.
CO4	Understand and diagnose engine maintenance and its trouble shooting.
CO5	Understand and diagnose the transmission, steering, braking, air conditioning and electrical systems.

CO-PO Mapping:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	2	1	1
CO2	2	1	3	2	2	1
CO3	3	3	3	3	2	3
CO4	2	1	3	2	3	1
CO5	2	1	3	2	1	1

Detailed Syllabus:

Introduction : Design of the body for safety, energy equation, engine location, deceleration of vehicle inside passenger compartment, deceleration on impact with stationary and movable obstacle, concept of crumble zone, safety sandwich construction.

Safety Concepts : Active safety, driving safety, conditional safety, perceptibility safety, operating safety, passive safety: exterior safety, interior safety, deformation behaviour of vehicle body, speed and acceleration characteristics of passenger compartment on impact.

Safety Equipments: Seat belt, regulations, automatic seat belt tightener system, collapsible steering column, tiltable steering wheel, air bags, electronic system for activating air bags, bumper design for safety.

Collision Warning And Avoidance : Collision warning system, causes of rear end collision, frontal object detection, rear vehicle object detection system, object detection system with braking system interactions.

Comfort And Convenience System : Steering and mirror adjustment, central locking system , Garage door opening system, tyre pressure control system, rain sensor system, environment information system.

Engine And Engine Subsystem Maintenance : Service of basic engine parts, cooling and lubricating system, fuel system, Intake and Exhaust system, electrical system - Electronic fuel injection and engine management service - fault diagnosis- servicing emission controls

Transmission And Driveline Maintenance: Clutch- general checks, adjustment and service- Dismantling, identifying, checking and reassembling transmission, transaxle- road testing- Removing and replacing propeller shaft, servicing of cross and yoke joint and constant

velocity joints- Rear axle service points- removing axle shaft and bearings- servicing differential assemblies- fault diagnosis.

Steering, Brake, Suspension, Wheel Maintenance: Inspection, Maintenance and Service of Hydraulic brake, Drum brake, Disc brake, Parking brake. Bleeding of brakes. Inspection, Maintenance and Service of Mc person strut, coil spring, leaf spring, shock absorbers. Dismantling and assembly procedures. Wheel alignment and balance, removing and fitting of tyres, tyre wear and tyre rotation. Inspection, Maintenance and Service of steering inkage, steering column, Rack and pinion steering, Recirculating ball steering service- Worm type steering, power steering system

Auto Electrical And Air Conditioning Maintenance: Maintenance of batteries, starting system, charging system and body electrical -Fault diagnosis using Scan tools. Maintenance of air conditioning parts like compressor, condenser, expansion valve, evaporator - Replacement of hoses- Leak detection- AC Charging- Fault diagnosis Vehicle body repair like panel beating, tinkering, soldering, polishing, painting.

Reading Books:

1. Bosch, "Automotive Handbook", 8 th Edition, SAE publication, 2011.
2. Ed May, "Automotive Mechanics Volume One" , McGraw Hill Publications, 2003
3. Ed May, "Automotive Mechanics Volume Two" , McGraw Hill Publications, 2003
4. Vehicle Service Manuals of reputed manufacturers
5. JullianHappian-Smith 'An Introduction to Modern Vehicle Design' SAE, 2002
6. Johnson, W., and Mamalis, A.G., "Crashworthiness of Vehicles, MEP, London, 1995
7. Rollover Prevention, Crash Avoidance, Crashworthiness, Ergonomics and Human Factors", SAE Special Publication, November 2003.

ME5171	DESIGN OF HEAT TRANSFER EQUIPMENT	3 - 0 - 0 (3 Cr)

Pre - Requisites: Nil

Course Outcomes:

CO1	Understand the physics and the mathematical treatment of typical heat exchangers
CO2	Apply LMTD and Effectiveness - NTU methods in the analysis of heat exchangers
CO3	Design and analyze the shell and tube heat exchanger.
CO4	Apply the principles of boiling and condensation in the design of boilers and condensers
CO5	Design cooling towers from the principles of psychrometry

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2		1
CO2	3	2	2	3		2
CO3	3	3	2	2		3
CO4	3	2	2	3		2
CO5	3	3	2	1		3

Detailed Syllabus:

Introduction to Heat Exchangers: Definition, Applications, Various methods of classification of heat exchangers with examples.

Governing Equation for heat exchangers: Derivation from steady-state steady-flow considerations.

Mathematical treatment of Heat Exchangers: Concept of Overall Heat Transfer Coefficient, Derivation of the concerned equations, Fouling, Fouling Factor, Factors contributing to fouling of a heat exchanger, Ill-Effects of fouling, Numerical Problems.

Concept of Logarithmic Mean Temperature Difference:Expression for single-pass parallel-flow and single-pass counter flow heat exchangers – Derivation from first principles, Special Cases, LMTD for a single-pass cross-flow heat exchanger – Nusselt's approach, Chart solutions of Bowman et al. pertaining to LMTD analysis for various kinds of heat exchangers, Numerical Problems, Arithmetic Mean Temperature Difference [AMTD], Relation between AMTD and LMTD, Logical Contrast between AMTD and LMTD, LMTD of a single-pass heat exchanger with linearly varying overall heat transfer coefficient [U] along the length of the heat exchanger.

Concept of Effectiveness: Effectiveness-Number of Transfer Units Approach, Effectiveness of single-pass parallel-flow and counter-flow heat exchangers, Physical significance of NTU, Heat capacity ratio, Different special cases of the above approach, Chart solutions of Kays and London pertaining to Effectiveness-NTU approach, Numerical Problems.

Hair-Pin Heat Exchangers: Introduction to Counter-flow Double-pipe or Hair-Pin heat exchangers, Industrial versions of the same, Film coefficients in tubes and annuli, Pressure drop, Augmentation of performance of hair-pin heat exchangers, Series and Series-Parallel

arrangements of hair-pin heat exchangers, Comprehensive Design Algorithm for hair-pin heat exchangers, Numerical Problems.

Shell and Tube Heat Exchangers: Single-Pass, One shell-Two tube [1S-2T] and other heat exchangers, Industrial versions of the same, Classification and Nomenclature, Baffle arrangement, Types of Baffles, Tube arrangement, Types of tube pitch lay-outs, Shell and Tube side film coefficients, Pressure drop calculations, Numerical Problems.

Principles of Boilers and Condensers: Boiling, Fundamentals and Types of boiling – Pool boiling curve, Various empirical relations pertaining to boiling, Numerical problems on the above, Condensation – Classification and Contrast, Types of condensers, Nusselt's theory on laminar film-wise condensation, Empirical Refinements, Several empirical formulae, Numerical problems.

Cooling Towers: Cooling towers – basic principle of evaporative cooling, Psychrometry, fundamentals, Psychrometric chart, Psychrometric Processes, Classification of cooling towers, Numerical problems.

Readings:

1. Kays, W. M. and London, A. L., Compact Heat Exchangers, 2nd Edition, McGraw – Hill, New York.
2. Donald Q. Kern: Process Heat Transfer, McGraw – Hill, New York.
3. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, 4th Edition, John Wiley and Sons, New York.

ME5172	NEW VENTURE CREATION	3 - 0 - 0 (3 Cr)

Pre - Requisites: Nil

Course Outcomes:

CO1	Understand entrepreneurship and entrepreneurial process and its significance in economic development.
CO2	Develop an idea of the support structure and promotional agencies assisting ethical entrepreneurship.
CO3	Identify entrepreneurial opportunities, support and resource requirements to launch a new venture within legal and formal frame work.
CO4	Develop a framework for technical, economic and financial feasibility.
CO5	Evaluate an opportunity and prepare a written business plan to communicate business ideas effectively.
CO6	Understand the stages of establishment, growth, barriers, and causes of sickness in industry to initiate appropriate strategies for operation, stabilization and growth.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3					2
CO2	2					2
CO3	3	2		1	1	2
CO4	2	3	2	2	2	2
CO5	2	3			2	2
CO6	2	2			2	2

Detailed Syllabus:

Entrepreneur and Entrepreneurship: Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises.

Planning a New Enterprise: Opportunity Scanning and Identification; Creativity and product development process; The technology challenge - Innovation in a knowledge based economy, Sources of Innovation Impulses – Internal and External; Drucker's 7 Sources of Innovation Impulses, General Innovation Tools, Role of Innovation during venture growth; Market survey and assessment; choice of technology and selection of site.

Establishing a New Enterprises: Forms of business organization/ownership; Financing new enterprises -Sources of capital for early-stage technology companies; Techno Economic Feasibility Assessment; Engineering Business Plan for grants, loans and venture capital.

Operational Issues in SSE: Develop a strategy for protecting intellectual property of the business with patent, trade secret, trademark and copyright law; Financial management issues; Operational/project management issues in SSE; Marketing management issues in SSE; Relevant business and industrial Laws.

Performance appraisal and growth strategies: Strategies to anticipate and avoid the pitfalls associated with launching and leading a technology venture; Management performance assessment and control; Causes of Sickness in SSI, Strategies for Stabilization and Growth.

Readings:

1. Byers, Dorf, and Nelson. 'Technology Ventures: From Ideas to Enterprise'. McGraw Hill. ISBN-13: 978-0073380186., 2010.
2. Bruce R Barringer and R Duane Ireland, 'Entrepreneurship: Successfully Launching New Ventures', 3rd ed., Pearson Edu., 2013.
3. D.F. Kuratko and T.V. Rao, 'Entrepreneurship: A South-Asian Perspective', Cengage Learning, 2013
4. S.S. Khanka, 'Entrepreneurial Development' (4th ed.), S Chand & Company Ltd., 2012.
5. Vasant Desai, 'Management of Small Scale Enterprises', Himalaya Publishing House, 2004.

ME5571	COMBUSTION AND EMISSION CONTROL	3 - 0 - 0 (3 Cr)

Pre - Requisites: Nil

Course Outcomes:

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	Apply control techniques for reduction of emission.
CO5	Identify and understand possible harmful emissions and the legislation standards

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2			1
CO2	2	2	3	2		2
CO3		1	3	2		1
CO4	2	2	3	2		2
CO5		1	3	2		1

Detailed Syllabus:

Combustion principles: Combustion – Combustion equations, heat of combustion - Theoretical flame temperature – chemical equilibrium and Dissociation -Theories of Combustion - Flammability Limits - Reaction rates – Laminar and Turbulent Flame Propagation in Engines. Introduction to spray formation and characterization.

Combustion in S.I engines : Stages of combustion, normal and abnormal combustion, knocking, Variables affecting Knock, Features and design consideration of combustion chambers. Flame structure and speed, Cyclic variations, Lean burn combustion, Stratified charge combustion systems. Heat release correlations.

Combustion in C.I. Engines: Stages of combustion, vapourisation of fuel droplets and spray formation, air motion, swirl measurement, knock and engine variables, Features and design considerations of combustion chambers, delay period correlations, heat release correlations, Influence of the injection system on combustion, Direct and indirect injection systems.

Combustion in gas turbines: Flame stability, Re-circulation zone and requirements - Combustion chamber configurations, Cooling, Materials.

Pollutant emissions from IC engines: Introduction to clean air, Pollutants from SI and CI Engines: Carbon monoxide, UBHCs, Oxides of nitrogen(NO-NO_X) and Particulate Matter, Mechanism of formation of pollutants, Factors affecting pollutant formation. Measurement of engine emissions-instrumentation, Pollution Control Strategies, Emission norms-EURO and Bharat stage norms. Emission control measures for SI and CI engines. Effect of emissions on environment and human beings.

Control techniques for reduction of emission : Design modifications – Optimization of operating factors – Fuel modification – Evaporative emission control - Exhaust gas

recirculation – SCR – Fumigation – Secondary Air injection – PCV system – Particulate Trap – CCS – Exhaust treatment in SI engines –Thermal reactors – Catalytic converters – Catalysts – Use of unleaded petrol.

Test procedure, instrumentation & emission measurement: Test procedures CVS1, CVS3 – Test cycles – IDC – ECE Test cycle – FTP Test cycle – NDIR analyzer – Flame ionization detectors – Chemiluminescent analyzer – Dilution tunnel – Gas chromatograph – Smoke meters –SHED test.

Readings :

1. Ramalingam, K.K., Internal Combustion Engines, SciTech Publications (India) Pvt. Ltd., 2004.
2. Ganesan, V, Internal Combustion Engines, Tata McGraw Hill Book Co., 2003.
3. John B. Heywood, Internal Combustion Engine Fundamentals, McGraw Hill Book, 1998.
4. B.P. Pundir I.C. Engines Combustion and Emission, 2010, Narosa Publishing House.
5. B.P. Pundir Engine Combustion and Emission, 2011, Narosa Publishing House.
6. Mathur, M.L., and Sharma, R.P., A Course in Internal Combustion Engines, DhanpatRai Publications Pvt.New Delhi-2, 1993.
7. Obert, E.F., Internal Combustion Engine and Air Pollution, International Text Book Publishers, 1983.
8. Cohen, H, Rogers, G, E.C, and Saravanamuttoo, H.I.H., Gas Turbine Theory, Longman Group Ltd., 1980.
9. Domkundwar V, A course in Internal Combustion Engines, DhanpatRai& Co. (P) Ltd, 2002.
10. Rajput R.K. Internal Combustion Engines, Laxmi Publications (P) Ltd, 2006.
11. Willard W. Pulkrabek, Engineering Fundamentals of the Internal Combustion Engines, 2007, Second Edition, Pearson Prentice Hall
12. Stephen, R. Turns., Combustion, McGraw Hill, 2005.
13. Mishra, D.P., Introduction to Combustion, Prentice Hall,2009
14. Sharma, S. P., Fuels and Combustion, Tata McGraw Hill, New Delhi, 2001.
15. Heywood, Internal Combustion Engine Fundamentals, McGraw Hill Co.1988

Warnatz, Ulrich Maas and Robert W. Dibble Combustion: Physical and Chemical Fundamentals, Modelling and Simulation, Experiments, Pollutant Formation,1999.

ME5572	ALTERNATE FUELS AND EMISSIONS	3 - 0 - 0 (3 Cr)

Pre - Requisites: IC Engines, Thermodynamics

Course Outcomes:

CO1	Categorize, interpret and understand the essential properties of fuels for IC engines
CO2	Identify the need for alternate fuels and characterize prospective alternate fuels
CO3	Evaluate the vehicle fuel storage and dispensing facility requirements.
CO4	Analyze the implement limitations with regard to performance, emission and materials compatibility.
CO5	Develop strategies for control of emissions as per the legislation standards.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1		2	3	2		2
CO2	2	2	3	2		2
CO3	2	2	2	2		2
CO4	3	3	3	3		2
CO5	2	3	3	2		2

Detailed Syllabus:

Introduction: Estimation of petroleum reserve – Need for alternate fuels – Availability and properties of alternate fuels, ASTM standards

Alcohols: General Use of Alcohols – Properties as Engine fuel – Gasolene and alcohol blends – Performance in SI Engine – Methanol and Gasolene blend – Combustion Characterstics in engine – emission characterstics

Vegetable oils: Soyabeen Oil, Jatropha, Pongamia, Rice bran, Mahuaetc as alternate fuel and their properties, Esterification of oils

Natural Gas, LPG: Availability of CNG, properties, modification required to use in engines – performance and emission characterstics of CNG using LPG in SI & CI engines.

Hydrogen : hydrogen production, Hydrogen as an alternative fuel, fuel cell
Automobile emissions & its control: need for emission control -Classification/ categories of emissions -Major pollutants - control of emissions – Evaluating vehicle emissions – EURO I,II,III,IV standards – Indian standards

Readings:

1. Richard L. Bechhold P.E., Alternate Fuels Guide Book, Society of Automotive Engineers, 1997
2. Norbeck, Joseph M., Hydrogen fuel for surface transportation, Society of Automotive Engineers, 1996
3. Wakefield, Earnest Henry , History of the Electric Automobiles: Hybrid Electric Vehicles

4. NorbePundir B.R., Engine Emissions: Pollutant formation and advances in control Technology, Narosa Publishing House
5. S.C. Bhatia , Air Pollution and its Control, Atlantic Publications, 2007
6. James D. Halderman, James Linder., Automotive Fuel and Emission Control, Prentice Hall
7. A.S.Ramadhas , Alternate Fuels for transportation, CRC Press

ME5276	MECHATRONICS AND ROBOTICS	3- 0 - 0 (3 Cr)

Pre-Requisites: Basic Electrical & Electronics, Mathematics and Design of machine Elements.

Course Outcomes:

CO1.	Model, analyze and control engineering systems.
CO2.	Select appropriate sensors, transducers and actuators to monitor and control the behavior of a process or product.
CO3.	Develop PLC programs for a given task.
CO4.	Evaluate the performance of mechatronic systems.
CO5.	Understand the evolution, classification, structures and drives for robots.

CO-PO Mapping:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2			2		2
CO2	3	2	2	2	2	2
CO3	2			2		1
CO4	1	1		2		2
CO5	1			2		1

Detailed Syllabus:

Introduction: Overview of the course, Examination and Evaluation patterns, History of Mechatronics, Scope and Significance of Mechatronics systems, elements of mechatronic systems, needs and benefits of mechatronics in manufacturing.

Sensors: Classification of sensors basic working principles, Displacement Sensor - Linear and rotary potentiometers, LVDT and RVDT, incremental and absolute encoders. Strain gauges. Force/Torque – Load cells. Temperature – Thermocouple, Bimetallic Strips, Thermistor, RTD Accelerometers, Velocity sensors – Tachometers, Proximity and Range sensors – Eddy current sensor, ultrasonic sensor, laser interferometer transducer, Hall Effect sensor, inductive proximity switch. Light sensors – Photodiodes, phototransistors, Flow sensors – Ultrasonic sensor, laser Doppler anemometer tactile sensors – PVDF tactile sensor, micro-switch and reed switch Piezoelectric sensors, vision sensor.

Actuators: Electrical Actuators : Solenoids, relays, diodes, thyristors, triacs, BJT, FET, DC motor, Servo motor, BLDC Motor, AC Motor, stepper motors. Hydraulic & Pneumatic devices – Power supplies, valves, cylinder sequencing. Design of Hydraulic & Pneumatic circuits. Piezoelectric actuators, Shape memory alloys.

Basic System Models & Analysis: Modelling of one and two degrees of freedom Mechanical, Electrical, Fluid and thermal systems, Block diagram representations for these systems.
Dynamic Responses of System: Transfer function, Modelling Dynamic systems, first order systems, second order systems.

Digital Electronics: Number systems, BCD codes and arithmetic, Gray codes, self-complimenting codes, Error detection and correction principles. Boolean functions using Karnaugh map, Design of combinational circuits, Design of arithmetic circuits. Design of Code converters, Encoders and decoders.

Signal Conditioning: Operational amplifiers, inverting amplifier, differential amplifier, Protection, comparator, filters, Multiplexer, Pulse width Modulation Counters, decoders. Data acquisition – Quantizing theory, Analog to digital conversion, digital to analog conversion.

Controllers: Classification of control systems, Feedback, closed loop and open loop systems, Continuous and discrete processes, control modes, Two step Proportional, Derivative, Integral, PID controllers.

PLC Programming: PLC Principles of operation PLC sizes PLC hardware components I/O section Analog I/O section Analog I/O modules, digital I/O modules CPU Processor memory module Programming. Ladder Programming, ladder diagrams, timers, internal relays and counters, data handling, analogue input and output. Application on real time industrial automation systems.

Case studies of Mechatronics systems: Pick and place robot, Bar code, Engine Management system, Washing machine etc.

Robotics: Introduction to Robotics, Robot anatomy physical configurations, Manipulator, Kinematics, Technical features. Programming of Mobile robot, robot programming language, end effecters.

READING:

1. W. Bolton, "Mechatronics", 5 th edition, Addison Wesley Longman Ltd, 2010
2. DevdasShetty& Richard Kolk "Mechatronics System Design", 3rd edition. PWS Publishing, 2009.
3. Alciatore David G &Histand Michael B, "Introduction to Mechatronics and Measurement systems", 4th edition, Tata McGraw Hill, 2006.
4. Saeed B Niku, "Introduction to Robotics: Analysis, Systems, Applications ", 2nd edition, Pearson Education India, PHI, 2003.

VIDEO REFERENCES:

1. http://video_demos.colostate.edu/mechatronics
2. http:// mechatronics.me.wisc.edu

ME5274	FLUID POWER SYSTEMS	3- 0 - 0 (3 Cr)

Pre-Requisites: Nil

Course Outcomes:

CO1	Understand common hydraulic components, their use, symbols, and mathematical models
CO2	Design, analyze and implement control systems for real and physical systems.
CO3	Design and analyze FPS circuits with servo systems, fluidic and tracer control.
CO4	Analyze the operational problems in FPS and suggest remedies.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	3	1	2
CO2	2	1	2	3	1	2
CO3	3	1	3	3	1	3
CO4	3	1	3	3	1	3

Detailed Syllabus:

Basic components: Introduction, Basic symbols, Merits, Demerits and applications, Pumps, actuators, Valves.

Hydraulic Circuits: Regenerative sequence, Semiautomatic, automatic Speed controls.

Power amplifiers and tracer control systems: Introduction and type of copying systems, Single coordinate parallel tracer control systems, tracer control systems with input pressure, tracer control systems with four edge tracer valve, Static and dynamic copying system, Types of tracer valve.

Design of Hydraulic circuits: Design of hydraulic circuits for various machine tools.
Servo system: Introduction and types, Hydro mechanical servo valve system, Electro hydraulic servo valve system, Introduction and evolution.

Fluidics: Introduction and evolution, Type of gates and their features, Applications of Fluidics.

Simulation: FPS implementation and analysis.

READING:
1. Esposito, Fluid power with applications, Pearson, 2011
2. M.Galalrabie, Rabie M "Fluid power Engg." Professional Publishing, 2009
3. John J Pippenger and W.Hicks, "Industrial hydraulics" Tata McGraw Hill, 1980.

ME5281	PRECISION MANUFACTURING	3 - 0 - 0 (3 Cr)

Pre - Requisites: Nil

Course Outcomes:

CO1	Understand the concept of accuracy and precision
CO2	Apply fits and tolerances for parts and assemblies as per ISO standards.
CO3	Evaluate the machine tool and part accuracies.
CO4	Estimate the surface quality of machined components

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3			2	2	1
CO2	3			2	2	1
CO3	3			2	2	1
CO4	3			2	2	1

Detailed Syllabus:

Accuracy and Precision: Introduction - Accuracy and precision – Need – application of precision machining- alignment testing of machine tools, accuracy of numerical control system, specification of accuracy of parts and assemblies.

Tolerance and fits: Tolerance and fits, hole and shaft basis system, types of fits- Types of assemblies-probability of clearance and interference fits in transitional fits.

Concept of part and machine tool accuracy: Specification of accuracy of parts and assemblies, accuracy of machine tools, alignment testing of machine tools.

Errors during machining: Errors due to compliance of machine-fixture-tool-work piece (MFTW) System, theory of location, location errors, errors due to geometric inaccuracy of machine tool, errors due to tool wear, errors due to thermal effects, errors due to clamping. Statistical methods of accuracy analysis.

Surface roughness: Definition and measurement, surface roughness indicators (CLA, RMS, etc,.) and their comparison, influence of machining conditions, methods of obtaining high quality surfaces, Lapping, Honing, Super finishing and Burnishing processes.

Readings:

1. R.L.Murty, ”Precision Engineering in Manufacturing”, New Age International Publishers, 1996.
2. V.Kovan, "Fundamentals of Process Engineering", Foreign Languages Publishing House, Moscow, 1975
3. Eary and Johnson, "Process Engineering for Manufacture"
4. J.L.Gadjala, "Dimensional control in Precision Manufacturing", McGraw Hill Publishers.

ME5386	DESIGN AND ANALYSIS OF EXPERIMENTS	3- 0 - 0 (3 Cr)

Pre-Requisites: Nil

Course Outcomes:

CO1	Formulate objective(s) and identify key factors in designing experiments for a given problem.
CO2	Develop appropriate experimental design to conduct experiments for a given problem.
CO3	Analyze experimental data to derive valid conclusions.
CO4	Optimize process conditions by developing empirical models using experimental data.
CO5	Design robust products and processes using parameter design approach.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	2		1
CO2	3		2	3		1
CO3	3	1	2	3		1
CO4	3		2	3		1
CO5	2		2	3		1

Detailed Syllabus:

Fundamentals of Experimentation: Role of experimentation in rapid scientific progress, Historical perspective of experimental approaches, Steps in experimentation, Principles of experimentation;

Simple Comparative Experiments: Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA;

Experimental Designs: Factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data;

Response Surface Methodology: Concept, linear model, steepest ascent, second order model, regression;

Taguchi's Parameter Design: Concept of robustness, noise factors, objective function & S/N ratios, inner-array and outer-array design, data analysis

READING:

1. Montgomery DC, Design and Analysis of Experiments, 7th Edition, John Wiley & Sons, NY, 2008.
2. Ross PJ, Taguchi Techniques for Quality Engineering, McGraw-Hill Book Company, NY, 2008.

ME5387	PROJECT MANAGEMENT	3- 0 - 0 (3 Cr)

Pre-Requisites: Nil

Course Outcomes:

CO1	Understand the importance of projects and its phases.
CO2	Analyze projects from marketing, operational and financial perspectives.
CO3	Evaluate projects based on discount and non-discount methods.
CO4	Develop network diagrams for planning and execution of a given project.
CO5	Apply crashing procedures for time and cost optimization.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		2	2		1
CO2	3	1	2	2		1
CO3	2	1	2			1
CO4	2	1	2	2	2	1
CO5	2	1	2	2		1

Detailed Syllabus:

Introduction: Introduction to Project Management, History of Project Management, Project Life Cycle.

Project Analysis: Facets of Project Analysis, Strategy and Resource Allocation, Market and Demand Analysis, Technical Analysis, Economic and Ecological Analysis.

Financial Analysis: Financial Estimates and Projections, Investment Criteria, Financing of Projects.

Network Methods in PM: Origin of Network Techniques, AON and AOA differentiation, CPM network, PERT network, other network models.

Optimisation in PM: Time and Cost trade-off in CPM, Crashing procedure, Scheduling when resources are limited.

Project Risk Management: Scope Management, Work Breakdown Structure, Earned Value Management, Project Risk Management.

READING:

1. Prasanna Chandra, Project: *A Planning Analysis*, Tata McGraw Hill Book Company, New Delhi, 4th Edition,2009.
2. Cleland, Gray and Laudon, *Project Management*, Tata McGraw Hill Book Company, New Delhi, 3rd Edition, 2007.
3. Clifford F. Gray, Gautam V. Desai, Erik W. *Larson Project Management* ,Tata McGraw-Hill Education, 2010

ME5471	TRIBOLOGICAL SYSTEMS DESIGN	3- 0 - 0 (3 Cr)

Pre-Requisites: Nil

Course Outcomes:

CO1	Analyze properties of lubricant and select proper lubricant for a given application.
CO2	Determine tribological performance parameters of sliding contact in different lubrication regimes.
CO3	Design and select appropriate bearings for a given application
CO4	Predict the type of wear and volume of wear in metallic and non-metallic surfaces.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	2
CO2	3	3	3	3	2	1
CO3	3	2	1	3	2	1
CO4	3	1	3	2		2

Detailed Syllabus:

Introduction: Overview of the course, history and basic concept of friction, wear and lubrication.

Lubricants: Types of lubricants, Objectives of lubricant, Physical properties of lubricants- **V**iscosity, Newtonian behavior of fluids, Non-Newtonian fluids, Oswald - de walle model, Bingham plastic fluids, Pressure – Temperature effects on viscosity, Viscosity index, Viscosity measurement, Lubricant density and Specific gravity, Thermal properties of lubricants, Temperature characteristics of lubricants, Selection of proper lubricant.

Lubrication modes: Modes of lubrication - hydrodynamic, hydrostatic, Elastohydrodynamic, mixed and boundary lubrication, Reynolds' equation, Applications of hydrodynamic lubrication theory - Journal bearing and Inclined thrust pad bearing, Hydrodynamic lubrication of roughened surfaces.

Theories of Lubrication: Theories of Externally pressurized lubrication, Squeeze-film lubrication, Elastohydrodynamic lubrication, Mixed lubrication and Air lubricated bearing, Rheological lubrication regime, Functional lubrication regime, Bearing types and its selection, Bearings design.

Friction and Wear: Contact between two bodies in relative motion, Origin of sliding friction, Types of wear and their mechanisms - Adhesive wear, Abrasive wear, Wear due to surface fatigue and wear due to chemical reactions, wear of non-metallic materials - Tribology of polymers, Tribology of polymer composites and Wear and friction of ceramics.

Text Books:

1. Stachowaik, G.W., Batchelor, A.W., *Engineering Tribology*, 3rd Ed., Elsevier, 2010.
2. Majumdar B.C, *Introduction to bearings*, S. Chand & Co., wheeler publishing, 1999.
3. Andras Z. Szeri, *Fluid film lubrication theory and design*, Cambridge University press, 1998.
4. Neale MJ, *Tribology Hand Book*, CBS Publications, 2012.
5. Williams JA, *Engineering Tribology*, Oxford Univ. Press, 2001.
6. Cameron A, *Basic lubrication theory*, Ellis Horwood Ltd., 2002.

ME5472	CONDITION MONITORING	3- 0 - 0 (3 Cr)

Pre-Requisites: Nil

Course Outcomes:

CO1	Understand effective maintenance schemes in industries.
CO2	Apply vibration monitoring techniques for system diagnoses.
CO3	Apply oil analysis technique to diagnose the wear debris.
CO4	Identify non conventional methods for machine diagnoses.
CO5	Develop modern technologies for effective plant maintenance.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3			
CO2	3		3	3	2	
CO3	3		3	3		
CO4	3		3	3	2	2
CO5	3		3			2

Detailed Syllabus:

Introduction: Failures – System, component and services failures – classification and its causes, Maintenance Schemes – objectives – types and economic benefits, break down, preventive and predictive monitoring.

Vibration Monitoring – causes and effects of vibration, review of mechanical vibration concepts – free and forced vibrations, vibration signature of active systems – measurement of amplitude, frequency and phase.

Vibration monitoring equipment– vibration sensors (contact and non-contact type) –factors affecting the choice of sensors, signal conditioners, recording and display elements, vibration meter and analyzers, measurement of overall vibration levels.

Contaminant analysis: Contaminants in used lubricating oils – monitoring techniques (wear debris) – SOAP technique, Ferrography, X-ray spectrometry, Particle classification.

Temperature Monitoring – Various techniques – thermograph, pyrometers, indicating paint and NDT methods.

Special Techniques: Ultrasonic measurement method, shock pulse measurement, Kurtosis, Acoustic Emission mentoring, critical speed analysis, shaft orbit analysis, Cepstrum analysis. Non-destructive techniques, Structural health monitoring weldments for surface and subsurface cracks

Reading:

1. Rao J. S., Vibration Condition Monitoring, Narosa Publishing House, 2/e 2000.
2. Isermann R., Fault Diagnosis Application, Springer-Verlag Berlin, 2011.
3. Allan Davis, Hand book of Condition Monitoring, Chapman and Hall, 2000.
4. Choudary K K., Instrumentation, Measurement and Analysis, Tata McGraw Hill.
5. Collacott, R. A., Mechanical Faults Diagnosis, Chapman and Hall, London, 1990

ME5483	COMPUTER AIDED DESIGN	3- 0 - 0 (3 Cr)

Pre-Requisites: Nil

Course Outcomes:

CO 1	Apply geometric transformations and projection methods in CAD.
CO 2	Develop geometric models to represent curves.
CO 3	Design surface models for engineering design.
CO 4	Model engineering components using solid modelling techniques for design.

CO – PO Mapping:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	2		3		2
CO 2	3	2		3		2
CO 3	3	2		3		2
CO 4	3	2		3		2

Detailed Syllabus:

Introduction: Introduction to CAE, CAD. Role of CAD in Mechanical Engineering, Design process, software tools for CAD, geometric modeling.

Transformations in Geometric Modeling: Introduction, Translation, Scaling, Reflection, Rotation in 2D and 3D. Homogeneous representation of transformation, Concatenation of transformations. Computer-Aided assembly of rigid bodies, applications of transformations in design and analysis of mechanisms, etc. Implementation of the transformations using computer codes.

Projections: Projective geometry, transformation matrices for Perspective, Axonometric projections, Orthographic and Oblique projections. Implementation of the projection formulations using computer codes.

Introduction to Geometric Modeling for Design: Introduction to CAGD, CAD input devices, CAD output devices, CAD Software, Display Visualization Aids, and Requirements of Modeling.

Curves in Geometric Modeling for Design: Differential geometry of curves**,** Analytic Curves, PC curve, Ferguson's Cubic Curve, Composite Ferguson, Curve Trimming and Blending. Bezier segments Bernstein polynomials, Composite Bezier. B-spline basis functions, Properties of basic functions, NURBS. Conversion of one form of curve to other. Implementation of the all the curve models using computer codes in an interactive manner.

Surfaces in Geometric Modeling for Design: Surfaces entities (planar, surface of revolution, lofted etc). Free-form surface models (Hermite, Bezier, B-spline surface).

Boundary interpolating surfaces (Coon's). Implementation of the all the surface models using computer codes.

Solids in Geometric Modeling for Design: Solid entities, Boolean operations, Topological aspects, Invariants. Write-frame modeling, B-rep of Solid Modeling, CSG approach of solid modelling. Popular modeling methods in CAD software. Data Exchange Formats and CAD Applications**:**

Reading:

1. Michael E. Mortenson, Geometric Modeling, Tata McGraw Hill, 2013.
2. A. Saxena and B. Sahay, Computer-Aided Engineering Design, Anamaya Publishers, New Delhi, 2005.
3. Rogers, David F., An introduction to NURBS: with historical perspective, Morgan Kaufmann Publishers, USA, 2001.
4. David F. Rogers, J. A. Adams, Mathematical Elements for Computer Graphics, TMH, 2008.

ME5377	RELIABILITY ENGINEERING	3- 0 - 0 (3 Cr)

Pre-Requisites: Nil

Course Outcomes:

CO1	Understand the concepts of Reliability, Availability and Maintainability
CO2	Develop hazard-rate models to know the behavior of components.
CO3	Build system reliability models for different configurations.
CO4	Assess reliability of components & systems using field & test data.
CO5	Implement strategies for improving reliability of repairable and non-repairable systems.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2	2		
CO2	2		2	2		
CO3	2		2	2	2	1
CO4	3	1	2	3		1
CO5	2	1	2	2	2	1

Detailed Syllabus:

Introduction: Probabilistic reliability, failures and failure modes, repairable and non-repairable items, pattern of failures with time, reliability economics;

Component Reliability Models: Basics of probability & statistics, hazard rate & failure rate, constant hazard rate model, increasing hazard rate models, decreasing hazard rate model, time-dependent & stress-dependent hazard models, bath-tub curve;

System Reliability Models: Systems with components in series, systems with parallel components, combined series-parallel systems, k-out-of-m systems, standby models, load-sharing models, stress-strength models, reliability block diagram;

Life Testing & Reliability Assessment: Censored and uncensored field data, burn-in testing, acceptance testing, accelerated testing, identifying failure distributions & estimation of parameters, reliability assessment of components and systems;

Reliability Analysis & Allocation: Reliability specification and allocation, failure modes and effects and criticality analysis (FMECA), fault tree analysis, cut sets & tie sets approaches; **Maintainability Analysis:** Repair time distribution, MTBF, MTTR, availability, maintainability, preventive maintenance.

Reading:

1. Ebeling CE, An Introduction to Reliability and Maintainability Engineering, TMH, New Delhi, 2004.
2. O'Connor P and Kleymer A, Practical Reliability Engineering, Wiley, 2012.

ME5771	RE- ENGINEERING	3- 0 - 0 (3 Cr)

Course Outcomes:

CO1	Identify the steps involved in re-engineering of a given component.
CO2	Design and fabricate an existing component with suitable modifications as per customer's requirements.
CO3	Select and configure a suitable re-engineering system for inspection and manufacturing.
CO4	Apply the re-engineering techniques in aerospace, automobile and medical sectors.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1				3		
CO2	3	2	2	3	3	1
CO3	3				3	1
CO4	3		2	3	3	1

Detailed Syllabus:

Introduction to reverse engineering, Re-Engineering–The Generic Process

Geometric Modelling using Point Cloud Data: Point Cloud acquisition, Surface Modelling from a point clouds, Meshed or Faceted Models, Planar Contour Models, Points to Contour Models, Surface Models, Segmentation and Surface Fitting for Prismatic objects and Free Form Shapes.

Methodologies and Techniques for Re-Engineering: The Potential for Automation with 3-D Laser Scanners, What Is Not Re-Engineering, What is Computer-aided (Forward) Engineering, What Is Computer-aided Reverse Engineering, Computer Vision and Re-Engineering.

Re-Engineering–Hardware and Software: Contact Methods Noncontact Methods, Destructive Method.

Selecting a Re-Engineering System: The Selection Process, Some Additional Complexities, Point Capture Devices, Triangulation Approaches, "Time-of-flight" or Ranging Systems, Structured-light and Stereoscopic Imaging Systems, issues with Light-based Approaches, Tracking Systems, Internal Measurement Systems, X-ray Tomography, Destructive Systems, Some Comments on Accuracy, Positioning the Probe, Post processing the Captured Data, Handling Data Points, Curve and Surface Creation, Inspection Applications, Manufacturing Approaches.

Integration between Re-Engineering and Additive Manufacturing: Modeling Cloud Data in Re-Engineering, Data Processing for Rapid Prototyping, Integration of RE and RP for Layer-based Model Generation, Adaptive Slicing Approach for Cloud Data Modeling, Planar Polygon Curve Construction for a Layer, Determination of Adaptive Layer Thickness.

Re-Engineering in Automotive, Aerospace, Medical sectors: Legal Aspects of Re-Engineering: Copyright Law, Re-Engineering, Recent Case Law, Barriers to Adopting Re-Engineering. A discussion on a few benchmark case studies.

READING:

1. K. Otto and K. Wood, *Product Design: Techniques in Reverse Engineering and New Product Development*, Prentice Hall, 2001.
2. Raja and Fernandes,*Reverse Engineering: An Industrial Perspective*, Springer, 2008.
3. AnupamSaxena, BirendraSahay, *Computer Aided Engineering Design*, Springer, 2005.
4. Ali K.Kamrani and EmadAbouel Nasr, *Engineering Design and Rapid Prototyping*, Springer, 2010.

ME5479	OPTIMIZATION METHODS FOR ENGINEERING DESIGN	3 - 0 - 0 (3 Cr)

Prerequisites: Nil

Course Outcomes:

CO1	Formulate a design task as an optimization problem
CO2	Identify constrained and unconstrained optimization problems and solve using corresponding methods
CO3	Solve discontinuous optimization problems using special methods
CO4	Solve the nonlinear optimization problems with evolutionary methods

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	1		2
CO2	3	1	2	1		2
CO3	3	1	2	1		2
CO4	3	1	2	1		2

Detailed Syllabus:

Introduction to Optimization in Design: Problem formulation, Optimization problems in Mechanical Engineering, Classification of methods for optimization.

Single-variable Optimization: Optimal criteria, Derivative-free methods (bracketing, region elimination), Derivative based methods, root-finding methods.

Multiple-variable Optimization: Optimal criteria, Direct search methods (Box's, Simplex, Hooke-Jeeves, Conjugate methods), Gradient-based methods (Steepest Descent, Newton's, Marquardt's, DFP method). Formulation and Case studies.

Constrained Optimization: KKT conditions, Penalty method, Sensitivity analysis, Direct search methods for constrained optimization, quadratic programming, GRG method, Formulation and Case studies.

Specialized algorithms: Integer programming (Penalty function and branch-and-bound method), Geometric programming.

Evolutionary Optimization algorithms: Genetic algorithms, simulated annealing, Ant colony optimization, Particle swarm optimization.

Multi-objective Optimization: Terminology and concepts, the concepts of Pareto optimality and Pareto optimal set, formulation of multi-objective optimization problem, NSGA.

Case studies and Computer Implementation: Representative case studies for important methods and development of computer code for the same to solve problems.

READINGS:

1. Jasbir Arora, Introduction to Optimum Design, Academic Press, 2004
2. KALYANMOY DEB, OPTIMIZATION FOR ENGINEERING DESIGN: Algorithms and Examples, PHI, 2004.
3. Kalyanmoy Deb, Multi-Objective Optimization using Evolutionary Algorithms, Wiley, 2001.

ME5482	FINITE ELEMENT METHOD	3 - 0 - 0 (3 Cr)

Pre-Requisites: Nil

Course Outcomes:

CO1	Understand the Finite Element Formulation procedure for structural Problems.
CO2	Understand the representation and assembly considerations for Beam and Frame elements.
CO3	Analyze Plane stress, Plane strain, axi-symmetric Problems.
CO4	Formulate and solve simple heat transfer and fluid mechanics problems
CO5	Identify significant applications of FEM in Manufacturing.

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		2	2	2	2
CO2	3		2	2	2	
CO3	3		2	3		
CO4	3	2	2	2		
CO5	3		2			

Introduction: Historical Perspective of FEM and applicability to mechanical engineering problems.

Mathematical Models and Approximations: Review of elasticity, mathematical models for structural problems, Equilibrium of continuum-Differential formulation, Energy Approach-Integral formulation, Principle of Virtual work - Variational formulation. Overview of approximate methods for the solution of the mathematical models; Ritz, Rayleigh-Ritz and Gelarkin's methods. Philosophy and general process of Finite Element method.

Finite Element Formulation: Concept of discretization, Interpolation, Formulation of Finite element characteristic matrices and vectors, Compatibility, Assembly and boundary considerations.

Finite element Method in One Dimensional Structural problems: Structural problems with one dimensional geometry. Formulation of stiffness matrix, consistent and lumped load vectors. Boundary conditions and their incorporation: Elimination method, Penalty Method, Introduction to higher order elements and their advantages and disadvantages. Formulation for Truss elements, Case studies with emphasis on boundary conditions and introduction to contact problems.

Beams and Frames: Review of bending of beams, higher order continuity, interpolation for beam elements and formulation of FE characteristics, Plane and space frames and examples problems involving hand calculations.

Two dimensional Problems: Interpolation in two dimensions, natural coordinates, Isoparametric representation, Concept of Jacobian. Finite element formulation for plane stress plane strain and axi-symmetric problems; Triangular and Quadrilateral elements,

higher order elements, sub parametric, Isoparametric and superparametric elements. General considerations in finite element analysis of two-dimensionproblems. Introduction plate bending elements and shell elements.

Three Dimensional Problems: Finite element formulation for 3-D problems, mesh preparation, tetrahedral and hexahedral elements, case studies.

Dynamic Analysis: FE formulation in dynamic problems in structures using Lagrangian Method, Consistent and lumped mass models, Formulation of dynamic equations of motion and introduction to the solution procedures.

FEM in Heat Transfer and Fluid Mechanics problems: Finite element solution for one dimensional heat conduction with convective boundaries. Formulation of element characteristics and simple numerical problems. Finite element applications in one dimensional potential flows; Formulation based on Potential function and stream function.

Algorithmic Approach for problem solving: Algorithmic approach for Finite element formulation of element characteristics, Assembly and incorporation of boundary conditions. Guidelines for code development. Introduction to commercial FE packages.

Reading:

1. Seshu P, Textbook of Finite Element Analysis, PHI. 2004
2. Reddy, J.N., Finite Element Method in Engineering, Tata McGraw Hill, 2007.
3. SingiresuS.Rao, Finite element Method in Engineering, 5ed, Elsevier, 2012
4. Zeincowicz, The Finite Element Method for Solid and Structural Mechanics, 4th Edition, Elsevier 2007.

ME5686	NON-DESTRUCTIVE TESTING	3 - 0 - 0 (3 Cr)

Pre-Requisites: Nil
Course Outcomes:

CO1	Understand the principles of NDT methods
CO2	Identify appropriate nondestructive testing methods for failure identification
CO3	Utilize radiography to identify underlying failure sites
CO4	Analyze flaws using advanced eddy current methods
CO5	Utilize acoustic emission to identify leaks

CO-PO Mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3			
CO2			3	2		3
CO3			3	2		
CO4			3	2		
CO5			3	2		

Detailed Syllabus:

Introduction to NDT, Liquid penetrant test: Physical Principles, Procedure for penetrant testing, penetrant testing materials, Penetrant testing methods, sensitivity, Applications and limitations, typical examples.

Ultrasonic testing: Basic properties of sound beam, Ultrasonic transducers, Inspection methods, Techniques for normal beam inspection, Techniques for angle beam inspection, Flaw characterization techniques, Applications of ultrasonic testing, Advantages and limitations.

Thermography: Basic principles, Detectors and equipment, techniques, applications.

Radiography: Basic principle, Electromagnetic radiation sources, radiographic imaging, Inspection techniques, applications, limitations, typical examples.

Eddy current test: Principles, instrumentation for ECT, techniques, sensitivity, advanced eddy Current test methods, applications, limitations.

Acoustic emission: Principle of AET, Technique, instrumentation, sensitivity, applications, Acoustic emission technique for leak detection.

Magnetic particle inspection: Principle of MPT, Procedure used for testing a component, sensitivity, limitations.

NDT of Composites: Codes and Conventions - Difficulties - Few Case Studies.

READING:

1. Peter J. Shull ,*Nondestructive Evaluation: Theory, Techniques and Applications*, Marcel Dekkar, 2002.
2. P. Mclntire (Ed.), *Non Destructive Testing Hand Book*, Vol. 4, American Society for Non Destructive Society, 2010
3. ASM Metals Hand Book, *Non Destructive Testing and Quality Control,* Vol. 17, ASM, 1989.
4. ASM Metals Hand Book, *Non Destructive Testing and Quality Control,* Vol. 17, ASM, 1989.

ME5378	Industry 4.0 and IIoT	3 - 0 - 0 (3 Cr)

PRE-REQUISITES: Basic Electrical & Electronics.

Course Outcomes:

CO1	Explore how Industry 4.0 will change the current manufacturing technologies and processes by digitizing the value chain.
CO2	Understand the drivers and enablers of Industry 4.0.
CO3	Learn about various IIoT-related protocols.
CO4	Build simple IIoT Systems using Arduino and Raspberry Pi.

CO-PO Mapping:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	1	2	1
CO2	2		2	2	1	
CO3			3	3		1
CO4	3	2	3	3	1	1

Detailed Syllabus:

Introduction to Industry 4.0:

Industry 4.0: Globalization and Emerging Issues, The Fourth Revolution, LEAN Production Systems,Smart and Connected Business Perspective, Smart Factories, Industry 4.0: Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis

Introduction to IIoT
Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service(XaaS), Role of Cloud in IoT, Security aspects in IoT.

Elements of IIoT: Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

IIoT Application Development : Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured

data storage on cloud/local server, Authentication, authorization of devices. Case Studies: IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation

READINGS:

1. Vijay Madisetti, ArshdeepBahga, Ïnternet of Things, "A Hands on Approach", University Press. 2015.
2. Dr. SRN Reddy, RachitThukral and Manasi Mishra, "Introduction to Internet of Things: A practical Approach", ETI Labs, 2017
3. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 2017.
4. Adrian McEwen, "Designing the Internet of Things", Wiley, 2015.
5. Raj Kamal, "Internet of Things: Architecture and Design", McGraw Hill, 2017.
6. CunoPfister, "Getting Started with the Internet of Things", O Reilly Media, 2011.