M. TECH. DEGREE IN

AUTOMOTIVE ENGINEERING

SYLLABUS

FOR

CREDIT BASED CURRICULUM

DEPARTMENT OF MECHANICALENGINEERING

NATIONAL INSTITUTE OFTECHNOLOGYAGARTALA

TRIPURA – 799046, INDIA

M.Tech. Automotive Engineering (Syllabus Structure)

Program: M.Tech. Automotive Engineering					
Sl. No.	Course Code	Subject	Credit	Class hours per week	Marks
First Semester					
1		Advanced Mathematics for Engineers	4	3-1-0	100
2		Engine Combustion and Emissions	4	3-1-0	100
3		Automotive Transmission	4	3-1-0	100
4		Elective – I	4	3-1-0	100
5		Elective – II	4	3-1-0	100
6		Automotive Systems Laboratory	2	0-0-3	100
7		CAD/CAM Laboratory	2	0-0-3	100
8		Technical Writing and Seminar	1	0-0-2	100
		Total	25	28	800
Second Semester					
1		Vehicle Dynamics	4	3-1-0	100
2		Automotive Chassis and Body Engineering	4	3-1-0	100
3		Elective – III	4	3-1-0	100
4		Elective – IV	4	3-1-0	100
5		Project Preliminary	3	0-0-6	100
6		Automotive Simulation and Analysis Laboratory	2	0-0-3	100
7		Robotics and Mechatronics Laboratory	2	0-0-3	100
8		Comprehensive Viva Voce	2	0-0-0	100
	Total		25	28	800
Third Semester					
1		Project and Thesis – 1	10	0-0-0	100
Fourth Semester					
1		Project and Thesis – 2	20	0-0-0	300
		Total Credit	80	Total Marks	2000

Electives: M.Tech. Automotive Engineering					
Elective – I					
Sl. No.	Course Code	Subject	Credit	Class hours per week	Marks
1		Elective I: Viscous Fluid Mechanics	4	3-1-0	100
2		Elective I: Advance Thermodynamics	4	3-1-0	100
3		Elective I: Advanced Materials and Processing	4	3-1-0	100
Elective - II					
Sl. No.	Course Code	Subject	Credit	Class hours per week	Marks
1		Elective II: Computational Fluid Dynamics	4	3-1-0	100
2		Elective II: Finite Element Method	4	3-1-0	100
3		Elective II: Numerical Analysis and Computer Programming	4	3-1-0	100
4		Elective II: Engine Management Systems	4	3-1-0	100
Elective - III					
Sl. No.	Course Code	Subject	Credit	Class hours per week	Marks
1		Elective III: Alternative Fuels and Energy Systems	4	3-1-0	100
2		Elective III: Advanced Vibration	4	3-1-0	100
3		Elective III: Computational Methods in Fluid Flow and Heat Transfer	4	3-1-0	100
Elective - IV					
Sl. No.	Course Code	Subject	Credit	Class hours per week	Marks
1		Elective IV: Automotive Materials and Component Manufacturing	4	3-1-0	100
2		Elective IV: Engine Design and Development	4	3-1-0	100
3		Elective IV: Electric and Hybrid Vehicles	4	3-1-0	100
4		Elective IV: Product Design and Development	4	3-1-0	100

Program Outcomes (POs)

Automotive Engineering Post Graduate students are deemed to acquire:

PO1: An ability to independently carry out research and development work to solve practical problems in Automotive Engineering.

PO2: An ability to write and present a substantial technical report/document

PO3: Students should be able to demonstrate a degree of mastery in the area of Automotive Engineering. The mastery should be at a level higher than the requirements in the Bachelor program of Mechanical Engineering.

PO4: An ability to inculcate a research knowledge base through literature study, problem identification, analysis and interpretation related to automotive technology.

PO5: An ability to apply the acquired curriculum knowledge for participating and contributing to the design and development of components and processes in automotive systems meeting industrial needs, with due consideration to public health, safety along with social, cultural and environment considerations.

PO6: An ability to adapt, adopt and exploit appropriate techniques in contemporary modelling and optimization resources to further the cause of automotive engineering paradigms.

Programs Specific Outcomes (PSOs)

PSO1: Automotive Engineering Post Graduate Students will acquire competency in conventional and advanced automotive technical domains.

PSO2: Develop a research attitude with an interdisciplinary outlook through an integrated learning approach to cater to the contemporary and future needs of the automotive industry.

FIRST SEMESTER

ADVANCED MATHEMATICS FOR ENGINEERS

Semester: 1st M.Tech.	Credit: 4					
Course Name: Advanced Mathematics for Engineers	**L**	**T**	**P**	3	1	0

Course Objectives:

1) Solving optimization problems, boundary value problems viz. Heat equation, Wave equation & mathematical modeling which are very useful in engineering field.
2) Simulation modeling is used to solve mathematical models based on probabilistic and statistical methods related to real-world problems safely and efficiently
3) To solve homogeneous, non-homogeneous linear equation & numerical solution of partial differential equation.

Syllabus Content

Module 1:

Calculus of Variations: Variation and its properties, Euler‟s equation, Conditional extreme, Isoperimetric problems, Functional dependent on first and higher order derivatives, Functional dependent on functions of several independent variables, Some applications- Direct methods Ritz and Kantorovich methods, Eulers finite difference method.

Module 2:

Laplace Transform & Fourier Transform: Applications of fourier transform in solving initial & boundary value problems. Laplace equation, Heat equation & wave equation.

Module 3:

Hankel‟s Transform: Eliminating properties of Hankel transform, Hankel inversion, and transform theorem, Hankel transform of derivatives of functions, Parsevel‟s theorem.

Module 4:

Simulation: Types, case studies in various fields using simulation technique, simulation software‟s used, use of mathematical models based on probabilistic and statistical methods.

Module 5:

Partial Differential Equation: Formation of PDE, Solution of PDE, Equation solvable by direct integration, linear equation of first order, Non-linear equation of first order, Charpit‟s method, Homogeneous linear equations with constant co-efficient, Non-homogeneous linear equation, Non-linear equation of second order.

Module 6:

Solution of parabolic & Hyperbolic equations: Implicit & Explicit schemes, ADI methods, Nonlinear parabolic equations – iteration method, Solution of elliptic equation-Jaccobi method, Gauss Seidel & SOR method, Ricardson method, RKF4 method, Galarkin‟s method.

Module 7:

Introduction to finite element method & scope

Text Books:

i) Calculus of Variations with Applications, Gupta A.S, Prentice Hall India Learning Private Limited

ii) Stochastic Modeling: Analysis & Simulation, Barry L Nelson, Dover Books on Mathematics

iii) Advanced Differential Equations, M.D. Raisinghania, S Chand Publishing

iv) Numerical Analysis, S.A.Mollah, Books & Allied Ltd

Reference Books:

i) Advanced Engineering Mathematics, E. Kreyszig, John Wiley & Sons

ii) Numerical Methods in Engineering and Science, B. S. Grewal, Khanna Publishers

iii) Advanced Engineering Mathematics, H. K. Dass, S. Chand Publishing

Course Outcomes

CO-No.	Course Outcome	Module Covered
1	Students will be able to analyze and solve optimization problems in Engineering using different techniques.	**1**
2	Students will be able to solve the boundary value problems viz. Heat equation, wave equation	**2, 3**
3	Students will learn to analyze and compute mathematical models based on probabilistic and statistical methods	**4, 7**
4	Student can be able to solve homogeneous, non-homogeneous linear equations arising in Engineering problems	**5**
5	Student can be able to solve the problems of partial differential equation using numerical techniques	**6, 7**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	**3**	**-**	**2**	**3**	**2**	**-**	**-**	**-**
CO-2	**3**	**1**	**1**	**3**	**2**	**-**	**-**	**-**
CO-3	**3**	**2**	**2**	**3**	**2**	**-**	**-**	**-**
CO-4	**2**	**-**	**1**	**3**	**2**	**-**	**-**	**-**
CO-5	**1**	**-**	**1**	**3**	**2**	**-**	**-**	**-**

ENGINE COMBUSTION AND EMISSIONS

Semester: 1st	Credit: 4					
Course Name: Engine Combustion and Emissions	**L**	**T**	**P**	3	1	0

Course Objectives:

1. To introduce the concept of combustion phenomena in IC Engine
2. To develop the knowledge of thermodynamic modelling of combustion
3. To develop knowledge in formation of emission
4. To understand recent trends in emission control devices.

Syllabus Content:

Module 1: Thermodynamics of Combustion:

Premixed and diffusion combustion process in IC engines and gas turbines. First and Second Law of Thermodynamics applied to combustion- combustion Stoichiometry- chemical equilibrium, spray formation and droplet combustion. Chemical Kinetics of Combustion: Fundamentals of combustion kinetics, rate of reaction, equation of Arrhenius, activation energy. Chemical thermodynamic model for Normal Combustion. Flames: Laminar premixed – flame speed correlations- quenching, flammability, and ignition, flame stabilization, laminar diffusion flames, turbulent premixed flames-Damkohler number. Burning of Fuels: spray formation & droplet behavior, gas turbine spray combustion, direct injection engine combustion, detonation of liquid – gaseous mixture, combustion of solid fuels, 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.

Module2: 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.

Module3: Combustion in C.I. Engines:

Stages of combustion, vaporization 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.

Module 4: Pollutant emissions from IC engines:

Introduction to clean air, Pollutants from SI and CI Engines: Carbon monoxide, UBHCs, Oxides of nitrogen (NO-NOX) 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. Noise Emission-sources, measurement, and regulation.Design of noise abatement frameworks.

Module 5: 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.

Text Books:

i) Sara McAllister, Jyh-Yuan, Chen A. and Carlos Fernandez-Pello "Fundamentals of Combustion Processes" Springer, Mechanical Engineering Series, 2011

ii) Stiesch G., "Modelling Engine Spray and Combustion Process" Springer, Heat and Mass Transfer, 2003

iii) Ferguson, C.R. & Kirkpatrick A.T., "Internal Combustion Engines Applied Thermosciences" Wiley, 2015

Reference Books:

i) Ramalingam, K.K., "Internal Combustion Engines", SciTech Publications (India) Pvt. Ltd., 2004.

ii) Ganesan, V, "Internal Combustion Engines", Tata McGraw Hill Book Co., 2003.

iii) John B. Heywood, "Internal Combustion Engine Fundamentals", McGraw Hill Book, 1998.

iv) B.P. Pundir I.C. "Engines Combustion and Emission", Narosa Publishing House, 2010.

v) B.P. Pundir "Engine Combustion and Emission", Narosa Publishing House, 2011.

vi) Mathur, M.L., and Sharma, R.P., "A Course in Internal Combustion Engines", DhanpatRai

vii) Publications Pvt.New Delhi-2, 1993.

viii) Obert, E.F., "Internal Combustion Engine and Air Pollution", International Text Book Publishers, 1983.

ix) Cohen, H, Rogers, G, E.C, and Saravanamuttoo, H.I.H., "Gas Turbine Theory", Longman Group Ltd., 1980.

x) Domkundwar V, "A course in Internal Combustion Engines", DhanpatRai& Co. (P) Ltd, 2002.

xi) Rajput R.K. "Internal Combustion Engines", Laxmi Publications (P) Ltd, 2006.

xii) Willard W. Pulkrabek, "Engineering Fundamentals of the Internal Combustion Engines", Second Edition, Pearson Prentice Hall, 2007.

xiii) Stephen, R. "Turns., Combustion", McGraw Hill, 2005.

xiv) Mishra, D.P., "Introduction to Combustion", Prentice Hall, 2009

xv) Sharma, S. P., "Fuels and Combustion", Tata McGraw Hill, New Delhi, 2001.

xvi) Heywood, "Internal Combustion Engine Fundamentals", McGraw Hill Co. 1988

Course Outcomes:

At the end of course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Understand the concepts of combustion phenomena in energy conversion devices.	**1,2,3**
2	Apply the knowledge of adiabatic flame temperature in the design of combustion devices.	**1,2,3**
3	Identify the phenomenon of flame stabilization in laminar and turbulent flames.	**1,2,3**
4	Apply control techniques for reduction of emission.	**4**
5	Identify and understand possible harmful emissions and the legislation standards	**5**

CO-PO Mapping (Rate: scaleof 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	2	2	2	1	2	1	2
CO-2	1	1	1	1	2	2	1	2
CO-3	1	1	1	2	1	1	2	1
CO-4	1	2	1	2	1	1	1	1
CO-5	1	2	1	1	1	2	2	1

AUTOMOTIVE TRANSMISSION

Semester: 1st	Credit: 4					
Course Name: Automotive Transmission	**L**	**T**	**P**	3	1	0

Course Objectives:

1. To introduce various types of Gear Box, its principle and applications
2. To understand the construction, principle and concept of Fluid Coupling & Torque Convertor
3. To understand the concept of epicyclic gear system and its types, overdrives
4. To gain knowledge about the concepts of hydrostatic drive, its merits and demerits and the electric drive commonly used in buses
5. To understand the construction and working of the most commonly used automatic transmission systems and its advantage over the conventional transmission

Syllabus Content:

Module 1: Clutch and Gear Box:

Clutch: Different types of Clutches, Working Principle and Constructions, Torque Capacity and Design of Clutch Plate. Gear Box: Performance of vehicle, total resistance to motion, Traction and Tractive effort, acceleration, calculation of gear ratio, design of three speed Gear Box, design of four speed Gear Boxes.

Module2: Automotive Transmission:

Spur and internal gear type Planetary Gear Boxes, Ford T- Model, Cotal and Wilson Gear Box, determination of Gear Ratios, Automatic Overdrives.

Module3: Hydrodynamic Drive:

Advantages and Limitations, Construction details, Torque Capacity, Slip in Fluid Coupling, Performance Characteristics, means to reduce drag torque in Fluid Coupling. Principal of Torque conversion, single, multi-stage and polyphase Torque Converters, Performance Characteristics, Constructional and Operational details of typical hydraulic Transmission Drives.

Module 4: Hydrostatic Drive and Electric Drive:

Hydrostatic Drives: Advantages and Disadvantages, Principles of Hydrostatic Drive Systems, Construction and Working of typical Hydrostatic Drives, Janney Hydrostatic Drive. Electrical Drives: Advantages and Limitations, Principles of Ward Leonard System of modern Electric Drive Systems for buses and Performance Characteristics.

Module 5: Automatic Transmission Applications:

Relative merits and demerits when compared to conventional transmission, Automatic Control of Gears, study of typical Automatic Transmissions, Ford & Chevrolet Drive, Automatic Control of Gear Box, Electronically Controlled Transmission and CVT Case Studies: GM‟s tap-shift Technology, Porsche Tiptronic Technology

Text Books:

i) Heldt P. M., "Torque Converters", Chilton Book Co., 1992

ii) Newton and Steeds, "Motor Vehicle", Illiffee Publishers, 2000.

Reference Books:

i) "Design Practices, Passenger Car Automotive Transmissions", SAE Handbook, 1994

ii) Challen Bernard, „Diesel Engine Reference Book", Oxford Butterworth, Heinemann, 1999.

iii) T. K. Garrett, K. Newton and W. Steeds, „Motor Vehicle", Butterworth, Heinemann, 13th Edition, 2000.

iv) J.B. Heywood, „Internal Combustion Engine Fundamentals", McGraw Hill Book Co., 2006.

Course Outcomes:

At the end of course, students will be able to

CO-No.	Course Outcome	Module Covered
1	To be able to differentiate various types of gear boxes, its working, advantages & limitations, gear ratios for real time applications of various gear boxes, epicyclic gear trains, its types, operations, merits and demerits	**1, 2**
2	To be able to understand and analyze the operation and performance of Fluid Coupling & Torque Converter under various parameters.	**3**
3	To understand the need, working, construction and the principle of overdrives, hydrostatic drive, Janny"s hydrostatic drive and also their merit and demerits.	**4**
4	To understand the concepts of electric drive & commonly used electric drive-in buses. To familiarize with the commonly used automatic transmission systems and to describe its construction and working.	**4**
5	To understand the advantages of automatic transmission over the conventional system	**5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	1	2	2	1	2	1	2
CO-2	1	2	1	1	2	1	1	2
CO-3	1	1	2	1	1	1	2	2
CO-4	2	2	1	2	1	1	1	1
CO-5	1	2	2	1	2	2	2	2

AUTOMOTIVE SYSTEMS LABORATORY

Semester: 1st	Credit: 2					
Course Name: Automotive Systems Laboratory	**L**	**T**	**P**	0	0	3

Course Objectives:

1) To gain an overall knowledge of various automotive system components and their functions.
2) To develop a hands-on experience about dismantling and assembling of different automotive system components.

List of Experiments

Exp 1: Dismantle and study the detail parts of a single cylinder SI and CI engine.
Exp 2: Study of gear box and clutch assembly with working principle.
Exp 3: Dismantle and analyse different parts of differential with working principle.
Exp 4: Analyze the in-detail operation of various steering mechanisms.
Exp 5: Perform load test and analyze the fuel consumption of a single cylinder engine.
Exp 6: Study of various emission measurement equipment with principle of operation.
Exp 7: Conduct performance emission analysis of a single cylinder test engine.
Exp 8: Study of automotive electrical and ignition system.
Exp 9: Fault diagnosis with possible remedy.

Course Outcomes:

At the end of course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Identify any component of automotive system with working principle.	**1**
2	Understand the correlation between clutch engagement and gear change mechanism.	**2**
3	Understand the role of differential in power transmission.	**3**
4	Differentiate between various steering mechanisms.	**4**
5	Correlate the effect of engine load with fuel consumption.	**5**
6	Gain in-hand experience to operate any emission measuring equipment.	**6**
7	Analyze the effect of load on performance emission characteristics of an engine.	**7**
8	Gain in depth knowledge about automotive lighting circuit.	**8**
9	Understand the possible cause of fault with required remedy.	**9**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	1	2	2	1	2	1	2
CO-2	1	2	1	1	2	1	1	2
CO-3	1	1	2	1	1	1	2	2
CO-4	2	2	1	2	1	1	1	1
CO-5	1	2	2	1	2	2	2	2
CO-6	2	1	2	2	1	2	1	2
CO-7	1	2	1	1	2	1	1	2
CO-8	1	1	2	1	1	1	2	2
CO-9	2	2	1	2	1	1	1	1

CAD/CAM LABORATORY

Semester: 1st	Credit: 2					
Course Name: CAD/CAM Laboratory	**L**	**T**	**P**	0	0	3

Course Objectives:

1) To create and manipulate geometric models using curves, surfaces and solids.
2) To create CNC Program for machining automotive engineering and machine tool engineering components.

List of Experiments

Exp 1 : Construction of 3D models of Machine Tool Components.

Exp 2 : Construction of 3D models of automotive engineering components.

Exp 3 : Construction of 3D assembly of machine tool and automotive engineering components.

Exp 4 : Preparation of drafting sheet for parts and assembly along with GD&T.

Exp 5 : Import and Export of CAD data. (IGES, STEP, Parasolid, STL, etc.)

Exp 6 : Preparation and Simulation of CAM program for CNC Milling Machine.

Exp 7 : Machining of Complex Profile using CNC Milling Machine

Exp 8 : Preparation and Simulation of CAM program for CNC Lathe Machine

Exp 9 : Machining of Complex Profile using CNC Lathe Machine

Exp 10 : Export of ready-to-run CNC-programs with no need for manual editing.

Course Outcomes:

At the end of this course, students will be able to

CO-No.	Course Outcome	Exp
1	Create 3D geometric models using Solid Works graphical software	1,2,5
2	Create 3D assembly drawing using Solid Works graphical software	3,5
3	Preparation of drafting sheet for Parts and Assembly along with GD&T.	4
4	Create Programs, simulate and to machine complex profile using CNC Machines	6,7,8,9
5	Generate codes using CAM Softwares	10

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	**3**			**2**	**-**	**2**	**3**	**-**
CO-2	**3**			**-**	**-**	**2**	**3**	**-**
CO-3		**3**		**-**	**-**	**2**	**3**	**-**
CO-4		**3**		**-**	**-**	**2**	**3**	**-**
CO-5			**3**	**-**	**-**	**2**	**3**	**-**

TECHNICAL WRITING AND SEMINAR

Semester: 1st	Credit: 1					
Course Name: Technical Writing and Seminar	**L**	**T**	**P**	0	0	2

Course Objectives:

1) To develop comprehensive technical communication skill.
2) To develop competency for communicating technical projects.

Syllabus Content:

Module 1: Report writing and other business communications:

Project writing, technical proposal, report Writing (Business and Technical Report), journal writing (Research Article), technical description.

Module2: Miscellaneous correspondence:

Process of communication, barriers in communication, written communication business letters (Quotations, Orders, Tenders, Complaint, Responding/reply to enquiry), email (email etiquettes), minutes, memorandum, circular, notice, agenda.

Module3: Job based communication:

Job application, resume writing, profile summary and employment interview, presentation skills.

Module4: Seminar presentation:

Preparation of PowerPoint slides and oral presentation for Seminar preparation on various technical innovations, recent developments in the field of automotive technology, topics of universal importance. Presentation of seminar on audio visual mode.

Text Books:

i) Sharma R C., Mohan Krishna, Business Correspondence and Report Writing. 5th ed. Chennai: Mc Graw Hill Education (India) Pvt. Ltd,2016.

Reference Books:

i) Padmaja T.V.S., Pfeiffer William Sanborn. Technical Communication. 6th ed. Noida: Pearson
ii) India Education Services Pvt. Ltd, 2008.
iii) Anderson V. Paul, Technical Communication.6th ed. New Delhi: Cengage Learning, 2010.

Course Outcomes:

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Ability of narrating any technical concept, communicating research article.	**1**
2	Develop overall experience of handling any official, business correspondence.	**2**
3	Self-development to communicate for any job prospects.	**3**
4	Ability to represent project report, thesis, technical viewpoint.	**4**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	1	1	2	1	1	1	2	2
CO-2	2	2	1	2	1	1	1	1
CO-3	1	2	2	1	2	2	2	2
CO-4	2	1	2	2	1	2	1	2

SECOND SEMESTER
VEHICLE DYNAMICS

Semester: 2nd	Credit: 4					
Course Name: Vehicle Dynamics	**L**	**T**	**P**	3	1	0

Course Objectives:

1) To provide a wide variety of learning about the dynamics of ground vehicles.
2) To apply the models established from basic theories for vehicle design and improvement
3) Identify key components and their working principles of modern vehicles

Syllabus Content:

Module 1: Introduction:

Hypothetical vehicle control loop, Fundamental Approach, Vehicle coordinates, motion variables. Forces – Dynamic axle loads, Static loads on level ground, hitch forces, Tire types, relative merits and demerits, tire dimensions and specifications, tire construction, size and load rating terminology,tread design , mechanics of force generation – problems.

Module2: 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. Aerodynamic forces on body, Total road loads – Fuel Economy Effects.

Module3: 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. effect of driving and braking torque on tier ,power consumed by a tire.

Module 4: 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 tire, wheel wobble, wheel wander, wheel shimmy, alignment toe in and toe out, tire wear and tire life.Ride characteristics of tires,

Module 5: 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.

Module 6: Suspension:

Vehicle dynamics and suspension requirements, choice of suspension spring rate, chassis springs and theory of chassis springs, Gas & hydraulic dampers and choice of damper, damper

characteristics, 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.

Textbooks:

i) Thomas D. Gillespie – Fundamentals of road vehicles - SAE, 1992
ii) Rao V Dukkipati, Road Vehicle Dynamics, SAE International , 2008

Reference Books:

i) JY. Wong- Theory of ground vehicles, Fourth edition ,Johnwiley and sons Inc, New York,2008
ii) Werner and Karl, Ground Vehicle Dynamics, Springer Berlin Heidelberg, 2008.
iii) Wong H, Theory of Ground Vehicles, McGraw Hill, Second edition, 2006.
iv) Amitosh De , Vehicle Dynamics, Galgotia Book Ltd., 2010.
v) Hans B Pacejka, Tire and Vehicle Dynamics,3rd Edition, Elsevier Ltd., 2012.
vi) J.G. Giles- steering, suspension and tyres, Wildlife books Ltd, London, 1968
vii) W. Steeds- Mechanics of road vehicles- Wildlife book Ltd, London, 1990
viii) Wolf- Heinrich Hucho – Aerodynamics of road vehicles, SAE

Course Outcomes:

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Understand the principles underlying the development and design of road vehicles under the influence of dynamic and static loads.	**1**
2	Demonstrate the Aerodynamic forces : lift & drag, Spoilers, Lift force, side force and roll, pitch and yaw moments, effects on Fuel Economy.	**2**
3	Analyze the performance and establish the design specifications for the acceleration and braking conditions.	**3**
4	Model, simulate and analyze the conventional road vehicles for better ride comfort.	**4**
5	Analyze the cornering forces and effects of tractive forces on cornering	**5**
6	Design suspension systems for better damping and comfort	**5,6**

CO-PO Mapping (Rate: scale of 1 to 3):

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	1	1	2	2	2	2	1
CO-2	2	2	1	1	1	1	1	1
CO-3	2	1	2	2	2	2	2	2
CO-4	2	2	2	2	1	2	2	2
CO-5	2	1	2	1	2	1	1	1
CO-6	2	2	2	2	2	2	2	2

AUTOMOTIVE CHASSIS AND BODY ENGINEERING

Semester: 2nd	Credit: 4					
Course Name: Automobile chassis and body engineering	**L**	**T**	**P**	3	1	0

Course Objectives:

1) To develop knowledge about various vehicle body types, materials and repair methods.
2) To acquire knowledge on different types of chassis layout and frame designs.
3) Gain in depth knowledge about steering, suspension, and braking system.
4) To understand the basics of wheels and tire.

Syllabus Content:

Module 1: Car body, body materials and trim mechanisms:

Classification of Car Body: Saloon-Convertibles-Limousine-Estate Car-Racing and Sports Car-Car Body Construction- Electric Car Body Construction-Steel Sheet-Timber-Plastic-GRP-Properties of Materials-Corrosion-Anticorrosion Methods-Selection of Paint and Painting Process-Body Trim Items- Body Mechanisms.

Module2: Commercial vehicle body and body repair:

Types of Bus Body: Based on Capacity-Distance Travelled and Construction-Layout for Various Types of Bus Body-Types of Metal Sections Used-Regulations-Constructional Details: Conventional and Integral-Driver Seat Design-Dimensions of Driver‟s Seat in Relation to Controls-Types of Commercial Vehicle Bodies-LCV-HCV - Electric Bus Body Construction-Panel Repair-Hand Tools-Power Tools-Repairing Sheet Metal and Repairing Plastics Body.

Module3: Layout, frame, front axle and steering system:

Basic Construction of Chassis, Types of Chassis Layout with Reference to Power Plant Location and Drive-Various Types of Frames-Loads Acting on Vehicle Frame-Materials for Frames-Types of Front Axles and Stub Axles-Front Wheel Geometry-Castor-Camber-King Pin Inclination and Toe In-Toe Out-Condition for True Rolling Motion-Ackerman‟s and Davis Steering Mechanisms- Reversible and Irreversible Steering-Over Steer and Under Steer- Different Types of Steering Gear Boxes- Power Assisted Steering.

Module 4: Suspension system, Wheels and tyres:

Requirements of Suspension System-Types of Suspension-Constructional Details and Characteristics of Single Leaf – Multi–Leaf Spring-Coil Spring and Torsion Bar-Rubber-Pneumatic and Hydro Elastic Suspension-Independent Suspension System-Shock Absorbers-Types of Wheels-Wheel Rims-Construction of Tyres and Tyre Specifications

Module 5: Braking system:

Need for Brake System-Stopping Distance-Leading and Trailing Shoes-Braking Torque-Types and Constructional Details-Drum Brakes and Disc Brakes-Hydraulic Braking System-Mechanical Braking System-Pneumatic Braking System-Power Assisted Braking System-Anti Lock Braking System.

Text Books:

i) Heinz Heisler, "Advanced Vehicle Technology", Butterworth-Heinemann, Elsevier, Indian Edition, 2011.
ii) Jack Erkavec "A System Approach to Automotive Technology", Cengage Learning India Pvt Ltd., 2009
iii) Kripal Singh, "Automobile Engineering (Volume-1)", 12th Edition, Standard Publishers Distributors, 2011.

Reference Books:

i) Donald E. Malen, „Fundamentals of Automobile Body Structure Design"SAE International, 2011.
ii) Geoff Davies, „Materials for Automobile Bodies", Butterworth-Heinemann, 2012.
iii) Powloski J, „Vehicle Body Engineering", Business Books Ltd., 1998.
iv) James E Duffy, „Body Repair Technology for 4-Wheelers",Cengage Learning, 2009.
v) Crouse and Anglin, „Automotive Mechanism", 9th Edition. Tata McGraw-Hill, 2003.
vi) Jack Erjavec, „A Systems Approach to Automotive Technology", Cengage Learning Pub.,2009
vii) T. K. Garrett, K. Newton and W. Steeds, „Motor Vehicle", Butterworth, Heinemann, 13th Edition, 2000.

Course Outcomes:

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Enumerate and identify different car body and body materials.	**1**
2	Describe the various commercial vehicle body, driver seat design and body repair tools.	**2**
3	Outline the design features of frame, front axle and steering system	**3**
4	Understand the types of suspension system, wheels, and tyres.	**4**
5	Illustrate the concepts, types, construction, and operation of different braking system used in automobiles.	**5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	2	1	2	2	2	1	1
CO-2	1	1	2	1	2	2	2	2
CO-3	2	1	1	2	1	1	1	1
CO-4	1	2	1	1	2	1	2	1
CO-5	2	1	2	2	1	2	2	1

AUTOMOTIVE SIMULATION AND ANALYSIS LABORATORY

Semester: **2nd**	Credit: 2					
Course Name: Automotive Simulation and Analysis Laboratory	L	T	P	0	0	3

Course Objectives:

1) To realize the importance of computational simulation of real time engine operation.
2) To gain in depth knowledge of working with various commercial simulation package for modeling and analysis of different real time engine operation.

List of Experiments

Exp 1: Introduction to Modeling and simulation, code development, and miscellaneous primary functions.

Exp 2: Familiarization with governing equations, initializing boundary function,model building and integration methods, gas exchange through valves, engine and porting geometry, exhaust gas recirculation, valve lift curves.

Exp 3: Developing simple model of driveline system and simulation.

Exp 4: Modeling and simulation of automotive suspension system.

Exp 5: Developing basic single cylinder model with intake ports and analysing the performance.

Exp 6: Developing multi cylinder engine model and investigating performance parameters.

Exp 7: Performing combustion simulation for analysing the pressure profile, maximum pressure rise rate corresponding to particular engine operation.

Exp 8: Analysing the rate of MFB, net heat release profile by simulation of real time engine operation.

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome	Expcovered
1	Develop basic concepts of modeling and coding.	**1**
2	Develop knowledge for handling governing equations, setting up boundary conditions, engine and porting geometry.	**1,2**
3	Gain experience of simulating basic driveline system.	**1,2,3**
4	Gain hands on experience of modeling and simulation of suspension system.	**4**
5	Develop the skill to analyze the performance characteristics of a developed engine model.	**5,6**
6	Analyze the combustion simulation profile of a real time engine operation.	**7,8**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	2	1	2	2	2	1	1
CO-2	1	1	2	1	2	2	2	2
CO-3	2	1	1	2	1	1	1	1
CO-4	1	2	1	1	2	1	2	1
CO-5	2	2	1	2	2	2	1	1
CO-6	1	1	2	1	2	2	2	2

ROBOTICS AND MECHATRONICS LABORATORY

Semester: 2nd	Credit: 2					
Course Name: Robotics and Mechatronics Laboratory	**L**	**T**	**P**	0	0	3

Course Objectives:

1) To impart basic knowledge and importance on Robotics and Mechatronics in Engineering Fields among the students.
2) To create the awareness on Robotics and Mechatronics in Research and Application area.

List of Experiments

Exp 1: To Study Robot motion in Cartesian, cylindrical and spherical co-ordinate system.
Exp 2: To study the pick and place motion on five axes robot.
Exp 3: Study of making a program on Labview with Push Button and Round LED.
Exp 4: Study of making a program on Labview with Loop and Logical function.
Exp 5: Study of making a program on Labview for Sound Accusation and again play.
Exp 6: Study of making a program on Labview for Comparison.
Exp 7: Study of making a program on Labview for power control of a DC motor.
Exp 8: Study of making a program on Labview for Temperature Acquisition.
Exp 9: Study of making a program on Labview for Voltage Acquisition.
Exp 10: Study of making a program on Labview for Current Acquisition.

Course Outcomes

CO-No.	Course Outcome	Exp
1	Robot motion in cartesian, cylindrical and spherical co-ordinate system.	1
2	Programming and control of five axis robots.	2
3	Programming for sound, temperature, voltage and current acquisition.	5,8,9,10
4	Programming for comparison and power control of DC motor.	6,7
5	Following features in Lab view software: While Loops, Plotting, SubVIs, Case Structures, Arrays, Clusters	4
6	Knowledge will be gained on application and utility of Robotics and Mechatronics used in various sectors and fields.	1-10

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	2	2	2	3	3	3	3
CO-2	2	2	2	3	3	2	3	3
CO-3	3	2	3	2	3	3	3	3
CO-4	2	2	2	3	3	2	3	3
CO-5	2	2	2	2	3	3	3	3
CO-6	2	2	3	3	3	2	3	3

COMPREHENSIVE VIVA

Semester: 2nd	Credit: 2					
Course Name: Comprehensive Viva	**L**	**T**	**P**	0	0	0

Course Objectives:

1) To assess the overall knowledge of the student in the field of Manufacturing Technology acquired over one year of study in post graduate program.

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome
1	Comprehend any given problem / concept related to Automotive Engineering domain.
2	Recall, recognize, visualize, demonstrate, criticize and appraise the concepts related to Automotive Engineering domain.

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	1	3	1	2	2	2	1
CO-2	3	2	3	2	1	2	2	2

PROJECT PRELIMINARY

Semester: 2nd	Credit: 4					
Course Name: Project Preliminary	**L**	**T**	**P**	0	0	6

Course Objectives:

1) To provide the opportunities to the student to demonstrate and develop concept/project in the respective Engineering Domain
2) To enable a student to work in cutting edge research problems in harmony.
3) To inculcate the practice of carrying research with ethics and safety.

Course Outcomes:

At the end of course, students will be able to

CO-No.	Course Outcome
1	Undergo literature survey in the chosen field of research
2	Approach and identify a research problem and able to analyze the scope of research
3	Develop a research methodology to proceed with the research
4	Summarize and present a technical presentation with proper reference

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	2	2	2	1	1	1	2
CO-2	2	2	2	2	2	1	2	2
CO-3	2	2	2	2	2	2	1	2
CO-4	1	2	2	2	2	1	1	1

THIRD SEMESTER

PROJECT AND THESIS - 1

Semester: 3rd	Credit: 10					
Course Name: **Project and Thesis – 1**	**L**	**T**	**P**	0	0	0

Course Objectives:

1) To provide the opportunities to the student to demonstrate and develop concept/project in the respective Engineering Domain
2) To enable a student to work in cutting edge research problems in harmony.
3) To inculcate the practice of carrying research with ethics and safety.

Course Outcomes

At the end of course, students will be able to

CO-No.	Course Outcome
1	Intensive literature survey and identify the research problems related to topic of interest.
2	Communicate and discuss research ideas
3	Develop a systematic model/approach to analyze and solve the research problems.
4	Outline the past, present and expected outcome based on systematic survey.
5	Conduct preliminary experiments / theoretical evaluation to certain extent.
6	Summarize their survey, research problem identification, approach, ,expected outcome and attained results with interpretation by means of oral presentation and written reports

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	3	2	2	2	2
CO-2	2	2	2	3	2	2	2	2
CO-3	2	2	2	2	2	2	2	2
CO-4	2	2	2	2	2	2	2	2
CO-5	2	2	2	2	2	2	1	1
CO-6	2	3	2	3	2	2	2	2

FOURTH SEMESTER

PROJECT AND THESIS - 2

Semester: 4th	Credit: 20					
Course Name: Project and Thesis – 2	**L**	**T**	**P**	0	0	0

Course Objectives:

1) To provide the opportunities to the student to demonstrate and develop concept/project in the respective Engineering Domain
2) To enable a student to work in cutting edge research problems in harmony.
3) To inculcate the practice of carrying research with ethics and safety.

Course Outcomes:

At the end of course, students will be able to :

CO-No.	Course Outcome
1	Survey, approach, identify and demonstrate the research / industrial problems using various available modern tools and techniques
2	Develop and validate a systematic model/process to analyze and solve the research problems.
3	Outline the past, present and expected performance / outcome of a material / product / process / model / system(s) in Engineering domain in confirmation to the standard of safety and environmental, economic and ethical yardstick.
4	Conduct experiments and theoretical evaluation extensively
5	Analyze, summarize, infer based on extensive research and communicate their chosen domain problems and result optimistically by means of oral presentation and written dissertation reports
6	Present and publish their findings as technical manuscript in technical conference/ indexed research journals ethically.

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	3	2	3	3	2
CO-2	2	2	2	3	2	3	2	2
CO-3	2	2	2	2	3	2	2	2
CO-4	2	2	2	3	2	2	2	2
CO-5	2	3	2	2	2	2	3	2
CO-6	3	3	2	3	2	2	2	3

ELECTIVE –I
Viscous Fluid Mechanics

Semester: 1st	Credit: 4					
Course Name: Viscous Fluid Mechanics	**L**	**T**	**P**	3	1	0

Course Objectives:

The course is intended to

1. Establish an understanding of the fundamental concepts of fluid mechanics.
2. Understand and apply the potential flow equations to basic flows.
3. Demonstrate and apply the differential equations of fluid mechanics including the impact of assumptions made in the analysis.
4. Understand the boundary layer concepts with respect to fluid flow
5. Understand and apply the compressible flow equations.

Syllabus Content

Module-1

Review of Basic concepts- Reynolds‟s transport theorem, Fluid kinematics – Physical Conservation laws – Integral and differential formulations, stress-deformation relation, vector and tensor calculus, vorticity and circulation, Potential flow, derivation of Navier-Stokes equations.

Module -2

Flow analysis: Navier-Stokes and energy equations, Exact solutions: Couette flow, Hagen-Poiseuille flow, Stoke‟s problems; Dimensionless forms and dimensionless numbers – Solution of Navier-Stokes equations.

Module-3

Boundary layer theory, Boundary layer thickness, Prandtl‟s equations, solution-skin Friction coefficient, Two-dimensional boundary layer, Blassius solution, Kármán-Pohlhausen method,

Module -4

Flow over bluff bodies, effect of pressure gradient, Flow separation and control.

Module-5

Flow instability: concept of small-perturbations, linearized stability of parallel viscous flows, different flow instabilities.

Module-6

Turbulent flows, RANS model, Reynolds stress tensor, Reynolds equation – Prandtl and von Karman hypothesis, Universal velocity Profile near a wall- flow through pipes, fully developed Turbulent flow through pipes and channel.

Text Books:

1. Fluid Mechanics, Pijush Kundu and Ira Cohen, 2nd edition, Academic press, An imprint of Elsevier Science.
2. Fluid Mechanics, Yunus A. CENGAL, 2nd edition. McGraw-Hill, 2010 .

References:

1. Currie, LG., Fundamental Mechanics of Fluids, 4th ed., CRC Press, 2012.
2. White, P.M., Viscous Fluid Flow, 2nd ed., McGraw-Hill, 1991.
3. Ockendon, H. and Ockendon, J., Viscous Flow, Cambridge Uni. Press, 1995.

Course Outcomes

CO-No.	Course Outcome	Module Covered
1	Formulate and solve basic problems of fluid mechanics	**1,2**
2	To identify, formulate and analyze specific fluid mechanics problems using the concepts of NS and exact solution.	**2, 3**
3	To solve and analyze practical problems suing appropriate approximations.	**3,4**
4	To understand and apply the concept of flow instabilities	**5**
5	Apply the concepts of turbulent flow analysis in important Engineering flow scenarios.	**5,6**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	2	3	3	2	2	-	-
CO-2	2	2	3	2	3	3	-	-
CO-3	2	3	3	3	2	2	-	-
CO-4	3	3	3	2	2	1	-	-
CO-5	3	2	3	3	3	1	-	-

Advance Thermodynamics

Semester: 1st	Credit: 4					
Course Name: Advance Thermodynamics	**L**	**T**	**P**	3	1	0

Course Objectives:

1) This course aims to provide a good platform to mechanical engineering students to understand, model and appreciate concept of dynamics involved in thermal energy transformation.
2) To prepare them to carry out experimental investigation and analysis at later stages of graduation.

Syllabus Content

Module 1:

Review of Thermodynamics: Introduction, Significance and limitations, System and Boundary, Simple System, Constraints and Restraints, Composite System, Phase, Homogeneous, Pure Substance, Amount of Matter and Avogadro Number, Mixture, Property, State, Equation of State, Standard Temperature and Pressure, Partial Pressure, Process, Vapor–Liquid Phase Equilibrium

Mathematical Background: Explicit and Implicit Functions and Total Differentiation, Exact (Perfect) and Inexact (Imperfect) Differentials, Mathematical Criteria for an Exact Differential.Relevance to Thermodynamics, Work and Heat, Integral over a Closed Path (Thermodynamic Cycle),Homogeneous Functions, Relevance of Homogeneous Functions to Thermodynamics, LaGrange Multipliers, Composite Function

Overview of Microscopic/Nano-thermodynamics: Matter, Intermolecular Forces and Potential Energy, Collision Number, Mean Free Path, and Molecular Velocity, Collision Number and Mean Free Path, Maxwellian Distribution of Molecular Velocity, Average, Root Mean Square (RMS), and Most Probable Speeds. Thermal and Internal Energy: Monatomic Gas, Diatomic Gas, Triatomic and Polyatomic Gases, Temperature, Pressure: Relation between Pressure and Temperature, Gas, Liquid, and Solid, Work, Heat Transfer and Thermal Equilibrium, Chemical Potential: Multi-component into Multi-component, Single Component into Multi-component, Boiling/Phase Equilibrium: Single Component Fluid, Multiple Components, Entropy: Overview, Energy Levels or Quantum Numbers, Macro- and Microstates and Entropy, Entropy of a Solid, a Liquid and a Gas, Relation between Entropy, Energy and Volume, Properties in Mixtures: Partial Molal Property, Stokes and Gauss Theorems: Gauss–Ostrogradskii Divergence Theorem, The Leibnitz Formula.

Module 2:

Laws of thermodynamics: Objectives.; First Law for a Closed System Energy Conservation Equation in Various Forms: Elemental Process, Integrated Form, Uncoupled (Conservative) and Coupled (Nonconservative) Systems Adiabatic Form and Caratheodary Axiom I, Cyclical Form and Poincare Theorem First Law in Rate Form, Quasi-Equilibrium (QE) and Nonquasi-Equilibrium (NQE) Processes, Enthalpy and First Law, Adiabatic Reversible Process for Ideal Gas with Constant Specific Heats. First Law for an Open System: Conservation of Mass, Conservation of Energy for a Simple Open System. Conservation of Energy for Complex Open System, Applications of First Law for an Open System, Integral and Differential Forms of Conservation

Equations. Second Law of Thermodynamics and Entropy, Consequences of the Second Law, Entropy Balance Equation for a Closed System, Irreversibility Entropy Measurements and Evaluation. Local and Global Equilibrium Entropy: Energy Relation for Single Component Incompressible Fluids, Third Law

Availability: Optimum Work and Irreversibility in a Closed System Availability or Exergy Analyses for a Closed System, Generalized Availability Analysis ,Availability/Exergetic Efficiency, Chemical Availability, Integral and Differential Forms of Availability Balance

Module 3:

Postulatory (Gibbsian) Thermodynamics: Introduction.. Classical Rationale for Postulatory Approach Simple Compressible Substance Legendre Transform Application of Legendre Transform.. Work Modes and Generalized State Relation Thermodynamic Postulates for Simple Systems

State Relationships for Real Gases and Liquids: Introduction, Equations of State, Virial Equations, Clausius-I Equation of State, VW Equation of State, Redlich–Kwong Equation of State, Other Two-Parameter Equations of State.. Compressibility Charts (Principle of Corresponding States), Boyle Temperature and Boyle Curves, Deviation Function. Three Parameter Equations of State; Critical Compressibility Factor (Zc)-Based Equations, Pitzer Factor, One Parameter Approximate Virial Equation, Redlich–Kwong–Soave (RKS or SRK) Equation, Robinson (PR) Equation Empirical Equations of State: Benedict–Webb–Rubin Equation, Beatie–Bridgemann (BB) Equation of State, Modified BWR Equation, Lee–Kesler Equation of State, Martin–Hou. State Equations for Liquids/Solids ,Cubic Equation

Module 4:

Thermodynamic Properties of Pure Fluids: Introduction, James Clark Maxwell, 1831–1879 Relations, Generalized Relations Evaluation of Thermodynamic Properties Pitzer Effect Kesler Equation of State (KES) and Kesler Tables Fugacity. Vapor/Liquid Equilibrium Curve Throttling Processes

Thermodynamic Properties of Mixtures: Introduction, Generalized Relations and Partial and Mixture Molal Properties. Partial Molal Property and Characteristics Useful Relations for Partial Molal Properties Ideal Gas Mixture Molal Properties Using the Equations of State

Module 5:

Stability: Introduction, Mathematical Criterion for Stability Perturbation of Energy Perturbation with Energy and Volume System with Specified Values of S, V, and m System with Specified Values of T, V, and m System with Specified Values of T, P, and m Application to Boiling and Condensation Entropy Generation during Irreversible Transformation Spinodal Curves

Chemically Reacting Systems**:** Introduction,Chemical Reactions and Combustion Thermochemistry First Law Analyses for Chemically Reacting Systems Combustion Analyses in the Case of Nonideal Behavior Second Law Analysis of Chemically Reacting Systems Mass Conservation and Mole Balance Equations

Module 6:

Thermodynamics and Biological Systems: Introduction,Biomass Processing Food and Nutrients: Thermo-chemical Properties of Nutrients, Metabolism of Nutrients Mixture of CH, F, and P,

Human Body. Metabolism, BMR Estimation Thermo-chemistry of Metabolism in BS Heat Transfer Analysis from the Body Temperature and Warm and Cold Blooded Animals Second Law and Entropy Generation in BS Entropy Generation through Chemical Reactions Life Span and Entropy Allometry

Text Books:

i) Beattie, J. A., and Oppenheim, I., Principle of Thermodynamics, New York: John Wiley, 1979.

ii) Annamalai, K., Puri, I. K., and Jog, Advanced Thermodynamics Engineering Biological Thermodynamics, Taylor& Francis, Boca Raton, FL, Aug. 2009.

Reference Books:

i) Callen, H. B. Thermodynamics: An Introduction to the Physical Theories of Equilibrium Thermostatistics and Irreversible Thermodynamics, New York: John Wiley, 1960.

ii) Cengel, Y. A., and M. A. Boles, Thermodynamics, an Engineering Approach, 3rd \ed., New York: McGraw-Hill Book Co., 1998.

iii) Gyftopoulos, E. P., and G. P. Beretta, Thermodynamics: Foundations and Applications, Mineola, NY: Dover,1991, 2005.

Course Outcomes

CO-No.	Course Outcome	Module Covered
1	Formulate and manipulate the thermodynamic treatment of arbitrary processes.	**1,2**
2	To identify, formulate, manipulate and analyze specific Mechanical Engineering problems using fundamental concepts.	**2.3**
3	To instill upon to envisage appropriate approximations for practical problem solving.	**3,4**
4	To investigate the effectiveness of energy conversion process in mechanical power generation for the benefit of mankind.	**4,5**
5	Understand the implications of approximations on the efficiency and accuracy of the solution.	**5,6**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PSO-1**	**PSO-2**
CO-1	1	2	1	1	1	1	2	1
CO-2	2	2	2	3	3	3	2	2
CO-3	2	1	2	2	3	3	2	1
CO-4	2	2	1	3	3	3	2	1
CO-5	2	2	2	2	3	3	2	2

ADVANCED MATERIALS AND PROCESSING

Semester: 1st	Credit: 4					
Course code and Name: Advanced Materials and Processing	**L**	**T**	**P**	3	1	0

Course Objectives:

1) To familiarize with the knowledge of different advanced materials
2) To study different manufacturing processes of advanced materials
3) To study the importance of advanced materials and their applications in engineering field

Syllabus Content

Module 1:

Introduction of advanced materials and its manufacturing processes for engineering applications.

Module 2:

Piezoelectric materials (PZT): piezoelectric effect, Di-electric hysterisis, piezoelectric constants, piezoelectric charge constants, dynamic behaviour of PZT transducers, piezoelectric materials and manufacturing techniques (stability, poling and depolarisation).

Module 3:

Shape memory alloys (SMA): Shape memory effect and the metallurgical phenomenon of SMA, Temperature assisted shape memory effect, Visco-elastic behaviour, magnetic shape memory effect. Various shape memory alloys. Manufacturing technology of SMAs.

Module 4:

Electro rheological (ER) and magneto-rheological (MR) materials: Characteristics of ER and EM fluids. ER and EM materials.

Module 5:

Composite materials: Design and manufacturing of polymer matrix, metal matrix and ceramic matrix composites. Various forms and type of reinforcements, fillers and additives.Design of composites for structural, wear resistance and high temperature applications.Micro-electromechanical (MEMS) systems.Introduction, characteristics of silicon wafers and other materials for MEMS applications.

Module 6:

Various manufacturing techniques of MEMS components Materials for high temperature applications: Ni-Cr alloys, ODS materials, Ni base and Co based super alloys, carbon-carbon composites. Diffusion bond coating of high temperature materials.

Module 7:

Powder metallurgy: Introduction and feature of powder metallurgy processes. Advanced solidification techniques: directional solidification, single crystal growth and levitation melting.

Text Books:

i) Gandhi, M.V., Thompson, B.S., Smart Materials and Structures, Chapman and Hall

ii) Ray, A.K. (ed), Advanced Materials, Allied publishers.

iii) Rama Rao, P. (ed), Advances in Materials and their applications, Wiley Eastern Ltd.

Reference Books:

i) R. E. Smallman, A. H.W. Ngan**,** Physical Metallurgy and Advanced Materials, Butterworth-Heinemann (Elsevier)

ii) Milton Ohring, Engineering Materials Science, Academic Press

iii) Smart Materials, Edited by Mel Schwartz, CRC Press

iv) Shape Memory Alloys, Edited By Dimitris C. Lagoudas, Springer Publications

v) James K. Wessel, Handbook of advanced materials, Wiley Online Library

Course Outcomes

CO-No.	Course Outcome	Module Covered
1	Provide and understanding about advanced materials and their applications in engineering field.	1
2	Develop a knowledge about advanced materials such as piezoelectric materials, shape memory alloys, ER, MR and composites and their manufacturing techniques and applications	2, 3, 4, 5
3	Design materials for different engineering applications	2, 5
4	Develop a knowledge about materials and their manufacturing techniques for MEMS applications	5, 6
5	Develop a knowledge on coating of high temperature materials, powder metallurgy process and advanced solidification techniques	6, 7

CO-PO Mapping (Rate: scale of 1 to3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	2	3	1	1	2	2	2
CO-2	1	2	3	2	2	2	2	3
CO-3	2	2	3	2	2	2	2	3
CO-4	2	2	3	1	2	2	3	2
CO-5	2	2	3	1	2	2	1	2

ELECTIVE - II

COMPUTATIONAL FLUID DYNAMICS

Semester: 2nd	Credit: **4**					
Subject Name: Computational Fluid Dynamics	L	T	P	**3**	**1**	**0**

Course Objectives:

1) Place CFD in the context of a useful design tool for industry and a vital research tool for thermos-fluid research across many disciplines;
2) Familiarize students with the basic steps and terminology associated with CFD. This includes developing students‟ understanding of the conservation laws applied to fluid motion and heat transfer and basic computational methods including explicit, implicit methods, discretization schemes and stability analysis;
3) Develop practical expertise of solving CFD problems with a commercial CFD code
4) Develop an awareness of the power and limitations of CFD.

Syllabus Contents

Module 1: Basic Thoughts

Philosophy of Computational Fluid Dynamics, the impact of Computational Fluid Dynamics – some other examples- Automobile and Engineering applications, Industrial Manufacturing applications, Civil Engineering applications, Environmental Engineering applications. The governing equations of fluid dynamics: their derivation, a discussion of their physical meaning and presentation of forms particularly suitable to CFD: Introduction, finite control volume, infinitesimal fluid element, the substantial derivative, divergence of velocity-its physical meaning, physical boundary condition, Comments on the conservation form, shock fitting & shock capturing. Comparison of FDM, FVM and FEM technique.

Module 2: Different Equations:

Mathematical Behavior of Partial Differential Equation – The Impact on CFD: Classification of quasi-linear partial differential equation, a general method of determining the classification of partial differential equations: the eigen value method, general behavior of the different classes of partial differential equation: impact on physical & computational fluid dynamics.

Module 3: Basics of the Numerical Discretization

Basic aspect of Discretization methods; finite difference and finite volume formulations, difference equation, explicit and implicit approaches: definition and contrasts, Errors and ananalysis of stability.

Module 4: Numerical Solutions

Numerical solution of elliptical equations - Linear system of algebraic equations, Numerical

solution of parabolic equations, Numerical solution of hyperbolic equations - Burgers equation.

Module 5: Some Simple CFD Techniques

The lax-Wendroff Technique, Mac Cormack‟s Technique, The Relaxation Technique & its use with Low-Speed Inviscid flow, Aspects of Numerical Dissipation and Dispersion; Artificial Viscosity, The Alternating Direction Implicit (ADI) Technique. Incompressible Navier-Stokes equations and algorithms - Basics of grid generation.

Text Books:

i) J.Andeson J.D., Computational Fluid Dynamics – The basics with applications, Mc Graw-Hill, 1995.

ii) Tannehill, J.e., Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, 2nd ed., Taylor & Francis, 1997.

ii) Hoffmann, K.A. and Chiang, S.T., Computational Fluid Dynamics for Engineers, Engineering Education Systems, 2000.

Reference Books:

i) Versteeg, H.K. and Malalasekera, W., An Introduction to Computational Fluid Dynamics – The finite volume method, Longman Scientific & Technical, 1995.

ii) Patankar, S.V., Numerical Heat Transfer & Fluid Flow, Hemisphere, 1980.

iii) 3.P.J. Roache, Fundamentals of Computational Fluid Dynamics.

Course Outcomes:

After going through careful explanations of concepts, numerous practical examples and figures, a student will be able to

CO-No.	Course Outcome	Module Covered
CO-1	Comprehensive, theory-based understanding, fundamentals of computational fluid dynamics and its application, Conceptual understanding ofmathematical behavior of partial differential equation and its impact on CFD.	1,2
CO-2	In-depth understanding ofbasic aspect of discretization methods and its applications.	2,3
CO-3	Application of established engineering methods to Numerical solutions.	3.4
CO-4	Understand Some Simple CFD Techniques.	4
CO-5	Understand and apply different algorithms, CFD technique and Basics of various grid generation.	1,4,5

Mapping of Course Outcomes with Program Outcomes:

CO	PO1	PO2	PO3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO1	3	3	3	2	3	2	3	2
CO2	3	3	3	2	3	2	3	2
CO3	3	3	3	2	3	2	3	2
CO4	3	3	3	2	3	2	3	2
CO5	3	3	3	2	3	2	3	2
CO6	**3**	**3**	**3**	**2**	**3**	**2**	**3**	**2**

FINITE ELEMENT METHOD

Semester: 1st	Credit: 4					
Course Name: Finite Element Method	**L**	**T**	**P**	3	1	0

Course Objectives:

1) Enable the student to analyze the engineering problems in the design process of solids and their structure.
2) Make the students to apply the knowledge of mathematics, science and engineering to do the analysis of simple and complex elastic structures using the finite element analysis
3) Derive the finite element equations for different mechanical elements.
4) Learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analysis.

Syllabus Content

Module1:

Introduction to FEM, basic concepts, historical back ground, applications of FEM, general description, comparison of FEM with other methods, variational approach, Glerkin‟s Methods. Co-ordinates, basic element shapes, interpolation function, Virtual energy principle, Rayleigh – Ritz method, properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions and characteristics, Basic equations of elasticity, strain- displacement relations.

Module2:

1-D Structural Problems: Axial bar element – stiffness matrix, load vector, temperature effects, Quadratic shape functions and problems. Analysis of Trusses: Plane Trusses and Space Truss elements and problems, Hermite shape functions **–** stiffness matrix – Load vector – Problems.

Module3:

Problems: CST, LST, force terms, Stiffness matrix and load vectors, boundary conditions, Isoparametric elements – quadrilateral element, shape functions – Numerical Integration. Finite element modeling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular elements. 3-D Problems: Tetrahedran element – Jacobian matrix – Stiffness matrix.

Module 4:

Steady state heat transfer: One dimensional heat conduction, Boundary condition, One dimensional element, Functional approach for heat conduction, ,Galarkins approach for heat conduction, One dimensional heat transfer in thin Fins, Two dimensional steady state heat conduction.

Module 5:

Scalar Field Problems: 1-D Heat conduction-Slabs – fins – 2-D heat conduction problems –

Introduction to Torsional problems.

Dynamic considerations, Dynamic equations – consistent mass matrix – Eigen Values, Eigen vector, natural frequencies – mode shapes – modal analysis**.**

Text Books:

i) Finite Element Methods: Basic Concepts and applications, Alavala, PHI.
ii) Introduction to Finite Elements in Engineering, Chandrupatla, Ashok and Belegundu, Prentice – Hall

Reference Books:

i) Concepts and Application of Finite Elements Analysis, Cook, Malkus and Plesha, Wiley.
ii) Bathe K.J., "Finite Element Procedures in Engineering Analysis", Prentice Hall of India
iii) O.C.Zienkiewicz, R.L.Taylor & J.Z.Zhu, "The Finite Element Method its Basis and Fundamentals", Butterworth-Heinemann, Elsevier
iv) Finite Element Method, J N Reddy, McGraw Hill International Edition.

Course Outcomes:

CO-No.	Course Outcome	Module Covered
1	Apply and understand the basic concepts of Finite element analysis procedure.	1, 2, 3 & 4
2	Analyze and build FEA model for complex engineering problems.	5
3	Knowledge of mathematics and engineering in solving the problems related to structural and heat transfer	4 & 5
4	Develop element characteristic equation and generation of global equation	1, 2, 3 & 4
5	Identify the application and characteristics of FEA elements such as bars, beams, plane and isoparametric elements	2 & 3

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO - 1	PSO - 2
CO-1	3	3	3	3	3	3	3	3
CO-2	3	3	2	3	2	3	2	1
CO-3	3	3	3	3	3	2	1	1
CO-4	2	2	3	3	2	3	2	2
CO-5	3	2	3	3	3	3	1	1

NUMERICAL ANALYSIS AND COMPUTER PROGRAMMING

Semester: 1st	**Credit:** 4					
Course Name: Numerical Analysis and Computer Programming	**L**	**T**	**P**	3	1	0

Course Objectives:

1) To be familiar with numerical solution of equations.
2) To get exposed to finite differences and interpolation.
3) To be through with the numerical Differentiation and integration.
4) To find numerical solutions of ordinary differential equation.
5) To find numerical solutions of partial differential equation.

Syllabus Content

Module 1:

Approximation and round off errors; Truncation errors and Taylor series.Determination of roots of polynomials and transcendental equations by Newton- Raphson, Secant and Barstow‟s method. Solution of linear simultaneous algebraic equations by Gauss elimination and Gauss-Siedel iteration methods.

Module 2:

Curve fitting; Linear and non-linear regression analysis. Finite Difference Method: Backward; Forward and central difference relations and their uses in numerical differentiation and integration; Application of different relations in the solution of partial differential equations, Introduction of Finite Element Method. Numerical solution of ordinary differential equations by Euler; modified Euler, Runge-Kutta and predictor-corrector method.

Module 3:

Introduction to computer programming in C and C++ languages: Arithmetic expressions; Simple programs Example of some C programs; Dissection of the program line by line; Concept of variables; Program statement and function calls from the library. C datatypes: int, char, float etc.

C expressions, arithmetic operations, relational and logic operations.

Module 4:

C assignment statements, extension of assignment to the operation; C primitive input output using getchar and putchar; exposure to the scanf and printffunction.C statements; conditional execution using if, else etc.(Optionally switch and break statements should be mentioned)

Module 5:

Concepts of loop; Example of loops in C using for-while and do-while(Optionally continue may be mentioned). One dimensional arrays and example of iterative programs using arrays; 2-d arrays; Use in matrix computations.

Module 6:

Concept of sub-programming; Functions; Example of functions; Argument passing mainly for the simple variables. Pointers, relationship between arrays and pointers; Argument passing using pointers. Array of pointer; Passing arrays as arguments. Strings and C string library. Structure and unions; Defining C structure; Passing structure as arguments (Programexamples) File I/O; Use of fopen, fsanf and fprintf routines.

Text Books:

i) C.Xavier: C Language and Numerical Methods.

ii) Dutta& Jana: Introductory Numerical Analysis.

iii) J.B.Scarborough: Numerical Mathematical Analysis.

iv) Jain, Iyengar ,& Jain: Numerical Methods (Problems and Solution).

Reference Books:

i) Balagurusamy: Numerical Methods, Scitech.

ii) Baburam: Numerical Methods, Pearson Education.

iii) N. Dutta: Computer Programming & Numerical Analysis, Universities Press

Course Outcomes

CO-No.	Course Outcome	Module Covered
1	An ability to apply knowledge of mathematics, science, and engineering. An ability to design and conduct experiments, as well as to analyze and interpret data.	1,2
2	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. An ability to function on multidisciplinary teams.	2.3
3	An ability to identify, formulates, and solves engineering problems. An understanding of professional and ethical responsibility	3,4
4	An ability to communicate effectively. The broad education necessary to understand the impact of engineering solutions in global, economic, environmental, and societal context.	4,5
5	Recognition of the need for, and an ability to engage in life-long learning. Knowledge of contemporary issues. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	5,6

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	1	2	2	1	1	1	1	2
CO-2	1	2	1	2	2	2	2	2
CO-3	2	1	2	3	3	3	2	1
CO-4	1	2	1	2	2	3	1	2
CO-5	2	2	2	3	3	2	2	2

ENGINE MANAGEMENT SYSTEMS

Semester: 1st	Credit: 4					
Course Name: Engine Management Systems	**L**	**T**	**P**	3	1	0

Course Objectives:

1) To introduce the automotive instruments and sensors
2) To develop the knowledge of measurement of engine parameter by using sensor
3) To understand the working of Electronic Ignition System
4) To develop the knowledge of Principles of Digital Control Systems
5) To understand the application of on-board diagnosis

Syllabus Content:

Module 1:

Sensors: Types- Air flow, pressure, temperature, speed, oxygen, detonation, position-principle of operation, arrangement, and material.

Module 2:

Gasoline Injection System: Open loop and closed loop systems, mono point, multi point and direct injection systems – principles and features, Bosch injection systems.

Module 3:

Diesel Injection System: Inline injection pump, Rotary pump and injector- Construction and principle of operation, common rail and unit injector system- Construction and principle of operation.

Module 4:

Ignition Systems: Ignition fundamentals, type of solid-state ignition systems, high energy ignition distributors, electronic spark timing and control.

Module 5:

Engine Mapping: Combined ignition and fuel management systems. Digital control techniques-dwell angle calculation, ignition timing calculations and injection duration calculations. Hybrid vehicles and fuel cells. Performance control of different types of engines in different vehicular frameworks including hybrid, electric and hydrogen vehicles.

Text Books:

i) Bosch Technical Instruction Booklets
ii) Tom Denton, Automotive Electrical and Electronic Systems, Edward Amold 1995

Reference Books:

i) Robert N Brady, Automotive Computers and Digital Instrumentation, Prentice Hall, 1988
ii) Duffy Smith, Auto Fuel Systems, The God Heart Willcox Company Inc., Publishers 1987
iii) Heinz Heilser, Advanced Engine Technology. SAE Publications 1995

Course Outcomes:

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	To understand the sensor classification and sensor product selection guide and measurements of automotive sensors	**1, 2**
2	To understand the working of pressure, position, flow, temperature, humidity, speed, acceleration, oxygen, torque, light, distance and level	**1, 2**
3	To differentiate the electronic fuel injection system in SI and CI engines and understand the advantages of using direct fuel injection over indirect fuel injection	**3, 4**
4	To develop an understanding of the advantages of electronic ignition system over the conventional ignition system	**3, 4**
5	To understand the algorithms for digital controllers	**5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	1	1	2	1	2	2	2	2
CO-2	2	1	1	2	1	1	1	1
CO-3	1	1	2	1	2	2	2	2
CO-4	2	1	1	2	1	1	1	1
CO-5	1	2	1	1	2	1	2	1

ELECTIVE - III
ALTERNATIVE FUELS AND ENERGY SYSTEMS

Semester: 2nd	Credit: 4					
Course Name: Alternative fuels and energy systems	**L**	**T**	**P**	3	1	0

Course Objectives:

1) To understand technological, environmental, and social impacts of alternative fuels and its production technologies.
2) To develop and compare the various Alternative fuels from different sources.

Syllabus Content

Module 1:

Introduction: Estimates of petroleum reserve, need for alternative fuel, Availability and comparative properties of alternate fuels, use of alcohols, LPG, Hydrogen, CNG and LNG, Vegetable oils and Biogas in automotive engines, Relative merits and demerits of various alternative fuels, Potential of Electronic vehicle, Solar car.

Module 2:

Alcohols: Manufacture of alcohols, Properties as engine fuels alcohols and gasoline blends, Performance in S.I engines: Methanol and gasoline blends, effects of compression ratio, alcohols in stratified charge engines, combustion characteristics in engines, reformed alcohols, Use in C.I Engines – Ignition accelerators, alcohols diesel emulsions, dual fuel systems, spark assisted diesel engines, surface ignition engines.

Module 3:

Natural Gas, LPG, Hydrogen: Availability of CNG, properties, Modification required to use in Engines, Performance and emission characteristics of CNG, Using LPG in SI and CI Engines, Performance and emission data for LPG, Hydrogen – production method, Storage and handling, Performance, Safety aspects.

Module 4:

Vegetable Oils and Biogas: Various vegetable oils for engines, Esterification performance in engines, Using biogas in engines, performance and emission characteristics, shale oil, coal liquid and Tars and fuel – Performance and Emission characteristics.

Module 5:

Electric Vehicle: Layout of an electric vehicle, Advantages and limitation specifications, System components, Electric control system, High energy and power density batteries, Hybrid vehicles.

Module 6:

Sterling Engine and its Systems: Constructional and Operational aspects.

Text Books:

i) Ganesan, V., ―Internal Combustion Engines", 2nd ed., Tata McGraw-Hill, 2003.

ii) Sharma, Mathur,. ―Internal Combustion Engines‖, Dhanpat Rai & Sons.

iii) Michael F. Hordeski -Alternative Fuels: The Future of Hydrogen

iv) M.K. Gajendra Babu, K.A. Subramanian--Alternative Transportation Fuels Utilisation in Combustion Engines

Reference Books:

i) Heywood J. Internal combustion engine Fundamentals. McGraw-Hill; 1988

ii) Richard Stone. Introduction to Internal Combustion Engines, THE MACMIILLAN PRESS .

iii) Arthur H. Lefebvre, Dilip R. Ballal---Gas Turbine Combustion: Alternative Fuels and Emissions, Third Edition

iv) Handbook of Alternative Fuel Technologies Edited BySunggyu Lee, James G. Speight, Sudarshan K. Loyalka.

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	To investigates and compare different sources of alternative fuels.	**1-4**
2	To develop and study the production technologies and use of alcohols, biofuel, biogas, LPG and hydrogen in CI and SI engines	**1-4**
3	To compare the performance, combustion, and emission characteristics of different alternative fuels.	**1-4**
4	To study and investigates different aspects of electric vehicle and sterling engine.	**5,6**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	2	2	2	1	2	1	2
CO-2	1	1	1	1	2	2	1	2
CO-3	1	1	1	2	1	1	2	1
CO-4	1	2	1	2	1	1	1	1

ADVANCED VIBRATION

Semester: 2nd	Credit: 4					
Course Name: Advanced Vibration	**L**	**T**	**P**	3	1	0

Course Objectives:

1. Ability of perform harmonic analysis of systems with Fourier series expansions, frequency domain representations. Analysis of systems under hysteresis damping, coulomb damping and other different types of damping.
2. The ability to analyze and solve two degree of freedom systems with or without damping using Transfer function approach, problems using Laplace transforms.
3. To develop ability for analyzing response of systems under periodic force of irregular form, non periodic force. Understanding the convolution integral. Understanding the control of vibrations.
4. Ability to use different approach, Eigen value problem approach to generate the equation of motion for systems undergoing multidegree of freedom vibration. Understanding and performing Modal Analysis.
5. Understanding and analyzing vibration of continuous systems.
6. Understanding and performing numerical integration methods in vibration analysis. Develop ability to analyze a vibrating system with Finite Element Methods.

Syllabus Content

Module 1:

Free and forced vibration of systems. Rayleigh‟s energy methods. Characteristics Roots, root locus representations. Energy dissipated in viscous damping. Construction of dampers with linearization of non linear damper. Forced Vibration analysis of systems with hysteretic damping and coulomb damping. Harmonic analysis, Fourier series analysis, frequency spectrum, time and frequency domain representations.

Module 2:

Free and forced vibration analysis of two degree of freedom systems, coordinate coupling, semi definite systems. Self excitation and stability analysis of systems. Solutions of systems using Laplace transformations, frequency transfer functions. Related Numerical problems.

Module 3:

Response of first and second order systems under general periodic force. Response of systems under irregular periodic force, non periodic force. Response to an impulse, general forcing conditions, base excitations. Transient and steady state response. Vibration control, natural frequency control, vibration isolations, vibration absorbers. Solving related numerical problems.

Module 4:

Modeling of multi degree of freedom systems (free, forced, damped and undamped). Stiffness, flexibility and inertia influence coefficients. Lagrange‟s equations. Eigen value problem, solution of characteristics equations, orthogonality of normal modes. Modal analysis of undamped and damped systems undergoing forced vibrations. Standard Eigen value problems, Raleigh‟s Formula, Jacobi‟s method, Dunkerley‟s Formula. Solving related problems.

Module 5:

Transverse vibration of string and cable, Longitudinal vibration of rods, torsional vibration of shafts, Lateral Vibration of Beams (Timoshenko, Euler Bernoulli Beam), Membrane vibrations. Application of Rayleigh- Ritz method. Related problems.

Module 6:

Finite difference methods for simple systems. Central difference methods, Runge – Kutta method for single degree and multi degree of freedom systems. Response to irregular forcing conditions using numerical methods. Finite difference methods for continuous systems. Equation of motion of an element, mass, stiffness matrix and force vector formulations. Transformation of element matrices. Equation of motion of systems using finite elements, imposing boundary conditions. Problems solving with different systems.

Text Books:

i) "Mechanical Vibrations", S.S Rao; Pearson Publication.

Reference Books:

1. Mechanical Vibrations; Dr. Debabrata Nag; WILLEY INDIA
2. Mechanical Vibrations; J. S. Mehta & A.S. Kailey. S. Chand Publication
3. Theory of Vibrations with Applications; William. T. Thomson. Pearson

Course Outcomes

CO-No.	Course Outcome	Module Covered
1	Ability of perform harmonic analysis of systems with Fourier series expansions, frequency domain representations. Analysis of systems under hysteresis damping, coulomb damping and other different types of damping.	**1**
2	The ability to analyze and solve two degree of freedom systems with or without damping using Transfer function approach, problems using Laplace transforms.	**2**
3	To develop ability for analyzing response of systems under periodic force of irregular form, non periodic force. Understanding the convolution integral. Understanding the control of vibrations.	**3**
4	Ability to use different approach, Eigen value problem approach to generate the equation of motion for systems undergoing multidegree of freedom vibration. Understanding and performing Modal Analysis.	**4**
5	Understanding and analyzing vibration of continuous systems.	**5**
6	Understanding and performing numerical integration methods in vibration analysis. Develop ability to analyze a vibrating system with Finite Element Methods.	**6**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO - 1	PSO - 2
CO-1			2	3			2	
CO-2			3	3			2	
CO-3			2	3			3	3
CO-4	3		3	3			2	
CO-5	3		3	3			2	
CO-6	3		3	3			3	3

COMPUTATIONAL METHODS IN FLUID FLOW AND HEAT TRANSFER

Semester: 2nd	Credit: **4**					
Subject Name: Computational Methods in Fluid Flow and Heat Transfer	L	T	P	**3**	**1**	**0**

Course Objectives:

1) Classification of the basic equations for fluid dynamics and heat transfer.
2) Discretization of transport equations for compressible and incompressible flow.
3) Finite volume methods for heat transfer and fluid flow in one and more dimensions: Diffusion, advection, convection-diffusion, Euler and Navier-Stokes equations.
4) Numerical solution of inviscid flow with modern upwind methods.
5) Numerical solution of the unsteady gas dynamical equations.
6) The SIMPLE and SIMPLER algorithms for the coupling of pressure and velocity for incompressible flow.
7) Steady state and unsteady problems.
8) Solution of algebraic systems of equations.
9) Basics of turbulence modeling and grid generation.
10) Introduction to a computational fluid dynamics (CFD) tool and application to heat and fluid flow.

Course Contents:

Module 1: Preliminaries

Review of Equations Governing Fluid Flow and Heat Transfer, Applied Numerical Methods, Numerical Solutions of Ordinary Differential Equations, Finite Differences, Discretization, Consistency, Stability and Fundamentals of Fluid Flow Modelling.

Module 2: Incompressible Flow and Heat Transfer

Finite Difference applications in heat conduction & convection, Solution of viscous incompressible flows by the stream function - vorticity formulation,

Module 3: Solution of Incompressible Flow:

Incompressible Navier-Stokes equations and algorithms - Basics of grid generation, Central Differencing of the Incompressible Navier-Stokes Equations, The need for a Staggered Grid, The Philosophy of the Pressure Correction Method, The Pressure Correction Formula, The numerical Procedure: The SIMPLE Algorithm, Boundary Conditions for the Pressure Correction Method

Module 4: Finite Volume Method& Finite Element Method

Governing Equations, Regular Finite Volumes, Approximations in the Discretization Technique, Discretization Procedure, Semi Explicit Method, Initial and Boundary Conditions, Implementation Issues, Solution Algorithm, Treatment of Complex Geometry, Application to Fluid Flow and Heat Transfer Problem. Weighted Residual and Variational Formulations, Rayleigh-Ritz Method, Interpolation, Numerical Integration

Module 5: Turbulence and its modeling

Introduction to turbulence, isotropic & anisotropic turbulence, The dynamics of turbulence, Classical idealization of turbulent flows, Structure of vortex dominated flows, Turbulence modeling, the k-€ model, the RNG k- € model and phase-averaged model, Modeling of near wall turbulent flows, Direct numerical simulation, Large eddy simulation of turbulence, turbulent modeling of compressible flows. Heat transfer for single-phase and for (multi-phase) phase change case.

Text Books:

i) Tannehill, J.E., Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, 2nd ed., Taylor & Francis, 1997.

ii) Muralidhar, K and T. Sundararaja, Computational Fluid flow and Heat Transfer, Second Edition, Narosa publishing house.

Reference Books:

i) Patankar, S.V., Numerical Heat Transfer & Fluid Flow, Hemisphere, 1980.

ii) Versteeg, H.K. and Malalasekera, W., An Introduction to Computational Fluid Dynamics – The finite volume method, Longman Scientific & Technical, 1995.

Course Outcomes:

After going through careful explanations of concepts, numerous practical examples and figures, a student will be able to

CO-No.	Course Outcome	Module Covered
1	Conceptual understanding of underpinning various mathematical models, consistency, stability and fundamentals of fluid flow modelling.	1,2
2	Express numerical modeling and its role in the field of fluid flow and heat transfer.	2,3
3	In-depth understanding of governing equations of FVM and application to fluid flow and heat transfer problem.	3,4
4	Knowledge of various governing equations of FEM and application to fluid flow and heat transfer problem.	4,5
5	Apply the various discretization methods, solution procedures and turbulence modeling to solve flow and heat transfer problems.	1,2,5

Mapping of Course Outcomes with Program Outcomes:

CO	PO1	PO2	PO3	PO-**4**	PO-**5**	PO-**6**	PSO-**1**	PSO-**2**
CO1	3	3	3	2	3	2	3	2
CO2	3	3	3	2	3	2	3	2
CO3	3	3	3	2	3	2	3	2
CO4	3	3	3	2	3	2	3	2
CO5	3	3	3	2	3	2	3	2

ELECTIVE - IV
AUTOMOTIVE MATERIALS AND COMPONENT MANUFACTURING

Semester: 2nd	Credit: 4					
Course Name: Automotive Materials and Component Manufacturing	**L**	**T**	**P**	3	1	0

Course Objectives:

1) To introduce the modern materials and alloys
2) To develop the knowledge of the properties of materials and its alloys
3) To develop knowledge in recent trends in manufacturing techniques of automobile components.

Syllabus Content:

Module 1: Engineering Materials:

Ferrous alloys-Iron-Iron carbide phase diagram with all phases & critical temperatures-steel, Types of steels-Effect of alloying elements on physical and chemical properties-Automotive applications- cast iron-Types-properties-factors affecting structures of cast iron-Automotive application. Nonferrous alloys- Al, Cu, Tin based alloys, Light metal alloys

Module 2: Modern materials and alloys:

Super alloys-super plastic alloys for auto body panels-refractory metals-shape memory alloys-dual phase steels-micro alloyed steels-high strength low alloy steels-smart materials - shape memory alloys- MEMS materials, Composite materials-ceramic –plastics-introduction, overview of processing, their characteristic features, Types and automotive application-Nano materials-Introduction and automotive applications, P and N type semiconductors, superconductors , soft and hard magnets.

Module 3: Surface modification of materials:

Mechanical surface treatment and coating- case hardening and hard facing-thermal spraying-Vapor deposition-ion implantation-diffusion coating-Electroplating and Electro less plating-Conversion coating-Ceramic and Organic coating-Diamond coating-Laser surface treatment-Selection of coating for Automotive applications.

Module 4: Engine materials and manufacturing:

Cylinder block and head-cylinder head and gasket-valves, seats and guides-piston and pin-piston ring and liner-connecting rod-gudgeon pins-crankshaft and bearing

Module 5: Transmission components Manufacturing:

Manufacturing of friction plates, Wheels, Brake drum, Gear, gearhobbling, shaping, powder metallurgy, orbital forming of spur, helical, and bevel gears, hypoid gears, heat treatment and finishing. Casting of gear box casing , Propeller shaft manufacturing. Forging of Rear axles.

Module 6: Recent Trends in manufacturing auto components:

Special processing techniques-Hydroforming-stretch forming-Recent developments in auto body panel forming-squeeze casting of pistons,Aluminum composite brake rotors-sinter diffusion bonded idler sprocket-Gas injection molding of window channel.

Text Books:

i) Callister W.D. (2006) "Material Science and Engineering- An introduction", Wiley –Eastern
ii) Kalpakjian,"Manufacturing and Engineering and Technology", Addison Wesloy, Publishing Company, 1995.

Reference Books:

i) Haslehurst.S.E., " Manufacturing Technology ", ELBS, London, 1990.
ii) Guy A.G," Elements of Physical Metallurgy", Oxford & IBH Pub. Co., 1990
iii) Flinn R. A. and Trojan P. K., (1999)"Engineering Materials and their Applications", Jaico.
iv) Sanjay K Mazumdar, "Composites Manufacturing", CRC Press, NY, 2003.
v) Kenneth Budinski – (1988) "Surface Engineering for wear resistance", Prentice Hall.
vi) Rusinoff, " Forging and Forming of metals ", D.B. Taraporevala Son & Co. Pvt Ltd., Mumbai,1995. . Sabroff.A.M. & Others, " Forging Materials & Processes ", Reinhold Book Corporation, New York,
vii) Upton, " Pressure Die Casting ", pergamon Press, 1985. High Velocity " Forming of Metals ", ASTME, prentice Hall of India (P) Ltd., New Delhi, 1990

Course Outcomes:

At the end of the course, students will be able to:

CO-No.	Course Outcome	Module Covered
1	Understand various materials and its alloys are formed and their classification based on atomic arrangement	**1, 2**
2	Understand the need for modern materials and its alloys	**1,2**
3	Demonstrate understanding ofSurface modification of materials and their techniques applications in automobile field.	**3**
4	Identify key benefits suitable Engine materials andmanufacturing process	**4**
5	Describe the mechanical behavior of different automotive Transmission Components, manufacturing process.	**5**
6	Identify recent trends in manufacturing Auto components	**4,5,6**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO - 1	PSO - 2
CO-1	2	1	1	2	1	1	1	1
CO-2	1	1	1	2	1	1	2	1
CO-3	1	2	2	1	2	2	2	2
CO-4	2	2	2	1	1	1	1	1
CO-5	2	2	2	2	2	2	2	2
CO-6	2	2	2	2	2	2	2	2

ENGINE DESIGN AND DEVELOPMENT

Semester: 2nd	Credit: 4					
Course Name: Engine Design and Development	**L**	**T**	**P**	3	1	0

Course Objectives:

1) To understand the basic concepts of S.I. and C. I. engine configuration and working principles.
2) To develop the knowledge of modern-day fuel injection systems and cooling and lubricating systems.
3) To understand the basic engine performance parameters and contemporary and pathways to improve the Thermal, Mechanical and Volumetric efficiency.

Syllabus Content:

Module 1: Parameters:

Compression ratio, Pressure volume and pressure crank angle diagram, frictional mean effective pressure, engine capacity, calculation of bore and stroke length, velocity and acceleration, gas force, inertia and resultant force at various crank angles–Side thrust on cylinder walls, Optimization criteria for improving Thermal, Mechanical and Volumetric efficiency.

Module 2: Design of Crank Train:

Design of Piston, piston rings, piston pin, Design of connecting rod; big end, small end and shank,Material and failures related to Cylinder, piston, connecting rod, design of crankshaft for light and heavy vehicle; Crankshaft, frontend, rear end journals,rank pin, Crank web. Design of flywheel; Speed fluctuation and stress calculations, turning moment diagram, design of hub, rim and arms of the flywheel, Ring gear Material and failures related to Crankshaft and flywheel.Design of gear box assembly-influence of engine design objectives.

Module 3: Design of Cylinder Head and Block:

Functional requirement, Block material like Gray Iron, Aluminum, Compacted Graphite Iron and Magnesium, Cylinder head alloys, Design layout, Basic block, Bulkhead design, and Cylinder liner design approach and Thermal loads, Cylinder arrangement.

Module 4: Design of Valve Train:

Effect of valve timing on engine performance, Number of Valves, Design of valves, Valve seat, Valve guide and cotter, Time selection of valveCam profile construction, Design of valve spring,Design of camshaft, Single and Double Overhead camshaft design, Design of valve gear train for variable valve timing.

Module 5: Design of Cooling, Lubrication, Intake, Exhaust and Fuel Injection System:

Design of cooling system, radiator, water pump, thermostat and fan, Computation of air-cooling system Engine friction and wear, Selection of lubricant, lubricating system, pump and filters, Design of intake and exhaust system, Design of fuel injection system for CI engine, Governor Design, Design of carburetor- electronic carburetor, Design of MPFI, GDI, CRDI system.

Text Books:

i) I. C. Engine & Air Pollution – E. F. Obert, Harper & Row Publishers, New York
ii) Engine Design – Giles J. G., Lliffe Book Ltd.
iii) Engine Design – Crouse, Tata McGraw Publication, Delhi
iv) I.C. Engine - Maleev V. L., McGraw Hill Book, Co.
v) I. C. Engine – L. C. Litchy, International Student Edition
vi) Design of Automotive Engine – A. Kolchin and V. Demidov
vii) I. C. Engine – Heywood.

Reference Books:

i) KevinL. Hoag , „VehicularEngineDesign“,SAE International,2005.
ii) A. Kolchin and V. Demidov, „Design of Automotive Engines“, MIR Publishers, Moscow,1984.
iii) R.K. Jain, „Machine Design“, Khanna Publishers, New Delhi,1997.
iv) „Design Data Book“, PSG College of Technology, Coimbatore,2000.
v) GilesJ. G „Engine Design“–., Life Book Ltd.2000
vi) Crouse„EngineDesign“TataMcGraw Publication, Delhi 2002.

Course Outcomes:

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Describe the various engine performance parameters	**1**
2	Construct crank train for the given specifications which includes the design of piston, connecting rod, crankshaft and flywheel	**2**
3	Calculate thermal loads and select a suitable material to design cylinder head and block	**3**
4	Select and design suitable valve train for the given specifications	**4**
5	Describe the design procedure involved in Cooling, Lubrication, Intake, Exhaust and Fuel Injection Systems	**5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	1	2	2	1	2	2	2	2
CO-2	2	1	1	2	1	1	1	1
CO-3	1	2	2	1	2	2	2	2
CO-4	1	1	2	1	2	2	2	2
CO-5	2	2	1	2	1	1	1	1

ELECTRIC AND HYBRID VEHICLES

Semester: 2nd	Credit: 4					
Course Name: **Electric and Hybrid Vehicles**	**L**	**T**	**P**	3	1	0

Course Objectives:

1) To understand the hybrid vehicle architectures and their technologies.
2) To understand the HEV and EV architectures, advantages and disadvantages
3) To develop knowledge in recent trends in Electrical and mechanical energy storage technologies including battery management considerations.

Syllabus Content:

Module 1: Introduction to Electric Vehicles:

Electric Vehicle – Need - Types – Cost and Emissions – End of life. Electric Vehicle Technology– layouts, cables, components, Controls, Batteries-overview and its types, Battery plug-in and life, Ultra-capacitor, Charging – Methods and Standards. Alternate charging sources –Wireless & Solar.

Module2: Electric Vehicle Motors:

Motors (DC, Induction, BLDC) – Types, Principle, Construction, Control. Electric Drive Trains (EDT) – Series HEDT (Electrical Coupling) – Power Rating Design, Peak Power Source (PPS); Parallel HEDT (Mechanical Coupling) – Torque Coupling and Speed Coupling, Switched Reluctance Motors (SRM) Drives – Basic structure, Drive Convertor, Design.

Module3: Electronics and Sensor-less control in EV:

Basic Electronics Devices – Diodes, Thyristors, BJTs, MOSFETs, IGBTs, Convertors, Inverters, Safety – Risks and Guidance, Precautions, High Voltage safety, Hazard management. Sensors - Autonomous EV cars, Self-Drive Cars, Hacking; Sensor less – Control methods- Phase Flux Linkage-Based Method, Phase Inductance- Based, Modulated Signal Injection, Mutually Induced Voltage-Based, Observer-Based.

Module 4: Hybrid Vehicles:

Hybrid Electric vehicles – Classification – Micro, Mild, Full, Plug-in, EV, Layout and Architecture – Series, Parallel and Series-Parallel Hybrid, Propulsion systems and components, Regenerative Braking, Economy, Vibration and Noise reduction, Hybrid Electric Vehicles System – Analysis and its Types, Controls.

Module 5: Fuel Cells for Electric vehicles:

Fuel cell – Introduction, Technologies & Types, Obstacles. Operation principles, Potential and I-V curve, Fuel and Oxidation Consumption, Fuel cell Characteristics – Efficiency, Durability, Specific power, Factors affecting, Power design of fuel Cell Vehicle and freeze capacity, Lifetime cost of Fuel cell Vehicle – System, Components, maintenance.

TextBooks:

i) Mehrdad Ehsani et al. (2005), "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", Power electronics and applications series, CRC press.

ii) Gianfranco Pistoia (2010), Electric and Hybrid Vehicles, Power Sources, Models, Sustainability, Infrastructure and the Market, © Elsevier 2010

Reference Books:

iii) Hybrid Electric Vehicle System Modeling and Control - Wei Liu, General Motors, USA,John Wiley & Sons, Inc., 2017.

iv) Hybrid Electric Vehicles – Teresa Donateo, Published by ExLi4EvA, 2017

v) Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure and theMarket Gianfranco Pistoia Consultant, Rome, Italy, Elsevier Publications, 2017.

vi) Modern Electric, Hybrid Electric, and Fuel Cell Vehicles,MehrdadEhsaniYiminGao StefanoLongo Kambiz M. Ebrahimi, Taylor & Francis Group, LLC, 2018.

vii) Hybrid, Electric & Fuel-Cell Vehicles Jack Erjavec, Delmar, Cengage Learning.

viii) Electric and Hybrid Vehicles, Tom Denton, Taylor & Francis, 2018.

Course Outcomes:

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Describe about working principle of electric vehicles.	**1, 2**
2	Understand the construction and working principle of various motors used in electric vehicles.	**1,2**
3	Understand about working principle of electronics and sensor less control in electric vehicles	**3**
4	Describe the different types and working principle of hybrid vehicles.	**4**
5	Illustrate the various types and working principle of fuel cells.	**5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	1	1	2	1	1	1	1
CO-2	1	2	2	1	2	2	2	2
CO-3	1	1	2	1	2	2	2	2
CO-4	2	2	1	2	1	1	1	1
CO-5	2	1	1	2	1	1	1	1

PRODUCT DESIGN AND DEVELOPMENT

Semester 2nd	Credit: 4					
Course Name: Product Design and Development	L	T	P	3	1	0

Course objectives: -

1. To impart basic concepts of product design and development processes
2. To understand the integration of customer requirements in product design.
3. To develop ability to apply structural approach to concept generation, selection and testing.
4. To understand various aspects of design such as product architecture industrial design, design for manufacturing and economic analysis.

Syllabus Content

Module 1: Introduction

Characteristics of successful product development, Challenges of product development, Structural approach to product development, Adapting generic product development process, Product development process flow.

Module 2: Product planning and customer needs

Product planning process, identifying opportunities, evaluation and prioritizing projects, resources allocation and plan timing, Pre-project planning, identifying customer needs, gathering of raw data from customers, interpreting to customer needs and establishing of relative importance of needs.

Module 3: Product specifications and concept generation Processes for establishing target specifications, methods for setting the final specifications, concept generation, screening and evaluation methods.

Module 4: Product architecture and industrial design

Methods of establishing product architecture, implications of product architecture, introduction to industrial design, study the impact of industrial design, Management of industrial design process and its quality assessment.

Module 5 : **Design for manufacturing and product development economics**

Definition, Estimation of Manufacturing cost, reducing the component costs and assembly costs, reducing system complexity - Prototype basics - Principles of prototyping, planning for prototypes, Economic Analysis of product development.

Text Books:

i) Product Design and Development, Karl T.Ulrich and Steven D.Eppinger, Anita Goyal, McGraw –Hill (2008)4th edition (SIE)

Reference Books:

i) Kevin Otto & Kristin Wood Product Design: "Techniques in Reverse Engineering and new Product Development." 1 / e 2004 , Pearson Education New Delhi
ii) Clive L.Dym, Patrick Little, "Engineering Design: A Project-based Introduction", Wiley; Fourth edition (1 January 2015)

Course Outcomes:

At the end of the course, students will be able to

CO No.	Course outcome	Module covered
1	Have the understanding of the processes involved in the product design and development.	1
2	Ability to evaluate customer needs and understand project planning	2
3	Ability to formulate product specifications and generate feasible concepts	3
4	Ability to apply industrial design principles in product development.	4
5	Ability to understand the product development for manufacturability and undertake economic analysis	5

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO - 1	PSO - 2
CO-1	3	1	1	3	2	2	1	1
CO-2	2	3	1	1	1	2	2	2
CO-3	2	1	2	2	2	1	1	2
CO-4	2	1	2	2	1	1	1	1
CO-5	2	1	2	2	3	3	3	2
CO-6	3	1	1	3	2	2	1	1