Group No.	Course Code	Course Title	UNIQUE CODE
1	20MAU13	Noise Vibration Harshness	201AU001
1	20MAU21	Vehicle dynamics	201AU002
1	20MAU23	Automotive body engineering & safety	201AU003
1	20MAU242	Vehicle performance	201AU004
1	20MAU251	Advanced Machine Design	201AU005
1	20MAU324	Vehicle Aerodynamics & Ergonomics	201AU006
1	20MCM11	Numerical methods for Engineers	201AU007
1	20MTP251	Solar thermal technologies and applications	201AU008
1	20CAE333	Design of Vibration control system	201AU009
1	20MST322	Manufacturing of Electronic Components	201AU010
2	20MAU12	Advances in Automotive engines & systems	202AU001
2	20MAU15	Alternative fuels, engine emission & emission control norms	202AU002
2	20MAU244	Engine management systems	202AU003
2	20MAU252	SI and CI Engine Processes Simulation	202AU004
2	20MAU254	Design of Heat Transfer Equipment	202AU005
2	20MTP323	Design and Analysis of thermal system	202AU006
2	20MCM333	Virtual Instrumentation	202AU007
2	20MSE332	Agile manufacturing	202AU008
2	20MTE321	Advanced moulding Techniques	202AU009
2	20MMD23	Tribology and Bearing Design	202AU010
3	20MAU11	Advanced Mathematical Methods in Engineering	203AU001
3	20MAU253	Computational fluid dynamics	203AU002
3	20MAU333	Finite Element Method	203AU003
3	20MTP332	Non conventional Energy Resources	203AU004
3	20MTP252	Modelling and Simulation of thermal system	203AU005
3	20MMD251	Automobile system Design	203AU006
3	20MST244	Advances in Material and Processing	203AU007
3	20CAE241	CIM and Robotics for automation	203AU008
3	20MTP14	Combustion Thermodynamics	203AU009
3	20MPM321	Rapid prototyping	203AU010
4	20MAU14	Automotive Chassis & power transmission	204AU001
4	20MAU22	Autotronics	204AU002
4	20MAU241	Driverless vehicles	204AU003
4	20MAU31	Hybrid and Electric vehicles	204AU004
4	20MTP15	Advanced power plant cycle	204AU005
4	20MTP331	Experimental methods in thermal power Engineering	204AU006
4	20MMD332	Design Optimization	204AU007
4	20MST333	Corrosion science and Technology	204AU008
4	20MAR252	Drives and control system for automation	204AU009
5	20MAU321	Automotive Embedded Systems	205AU001
5	20MAU322	Industry 4.0 And IIOT In Automotive Vehicles	205AU002
5	20MAU323	Advanced Manufacturing Technology	205AU003
5	20MAU334	Automotive Materials	205AU004

5	20MTP241	Energy conservation and management	205AU005
5	20MMD331	Smart Material and Structures	205AU006
5	20MST323	Non- traditional machines	205AU007
5	20MAR251	Networking and IOT	205AU008
5	20MTP324	Phase change phenomena in fluids	205AU009
5	20MTE251	Product Design technology	205AU010

6	20MAU243	Automotive control systems	206AU001
6	20MAU331	Machine Learning	206AU002
6	20MAU332	Artificial Intelligence	206AU003
6	20MTP253	Computational methods in Heat transfer and fluid Flow	206AU004
6	20MTP334	Thermal storage system	206AU005
6	20MTP322	Theory of I.C Engine	206AU006
6	20MMD333	Design of hydraulic and pneumatic system	206AU007
6	20CAE253	Design of Micro Electro Mechanical system	206AU008
6	20MMD324	Experimental Mechanics	206AU009
6	20MST31	Plastic Processing	206AU010

Visvesvaraya Technological University, Belagavi.
Ph.D Coursework Courses – 2020 in Automobile Engineering

Ph.D Coursework Courses under Group - 3			
SlNo	**Course Code**	**Course Name**	**Page**
1	20MAU11	Advanced Mathematical Methods in Engineering	39
2	20MAU253	Computational fluid dynamics	42
3	20MAU333	Finite Element Method	44
4	20MTP332	Non conventional Energy Resources	46
5	20MTP252	Modelling and Simulation of thermal system	47
6	20MMD251	Automobile system Design	48
8	20MST244	Advances in Material and Processing	49
9	20CAE241	CIM and Robotics for automation	50
10	20MTP14	Combustion Thermodynamics	52
11	20MPM321	Rapid Prototyping	54

Ph.D Coursework Courses under Group - 4			
SlNo	**Course Code**	**Course Name**	**Page**
1	20MAU14	Automotive Chassis & power transmission	54
2	20MAU22	Autotronics	56
3	20MAU241	Driverless vehicles	58
4	20MAU31	Hybrid and Electric vehicles	60
5	20MTP15	Advanced power plant cycle	62
6	20MTP331	Experimental methods in thermal power Engineering	63
7	20MMD332	Design Optimization	65
8	20MST333	Corrosion science and Technology	66
9	20MAR252	Drives and control system for automation	68

Ph.D Coursework Courses under Group - 5			
SlNo	**Course Code**	**Course Name**	**Page**
1	20MAU321	Automotive Embedded Systems	70
2	20MAU322	Industry 4.0 And IIOT In Automotive Vehicles	71
3	20MAU323	Advanced Manufacturing Technology	72
4	20MAU334	Automotive Materials	74
5	20MTP241	Engineering conservation and management	76
6	20MMD331	Smart Material and Structures	77
7	20MST323	Non- traditional machines	78
8	20MAR251	Networking and IOT	79
9	20MTP324	Phase change phenomena in fluids	80
10	20MTE251	Product Design technology	81

Ph.D Coursework Courses under Group - 6			
SlNo	**Course Code**	**Course Name**	**Page**
1	20MAU243	Automotive control systems	83
2	20MAU331	Machine Learning	85
3	20MAU332	Artificial Intelligence	86
4	20MTP253	Computational methods in Heat transfer and fluid Flow	87
5	20MTP334	Thermal storage system	89
6	20MTP322	Theory of I.C Engine	90
7	20MMD333	Design of hydraulic and pneumatic system	91
8	20CAE253	Design of Micro Electro Mechanical system	92
9	20MMD324	Experimental Mechanics	93
10	20MST31	Plastic Processing	95

Ph.D Coursework Courses under Group - 1			
SlNo	**Course Code**	**Course Name**	**Page**
1	20MAU13	Noise Vibration Harshness	5
2	20MAU21	Vehicle dynamics	7
3	20MAU23	Automotive body engineering & safety	9
4	20MAU242	Vehicle performance	11
5	20MAU251	Advanced Machine Design	12
6	20MAU324	Vehicle Aerodynamics & Ergonomics	14
7	20MCM11	Numerical methods for Engineers	16
8	20MTP251	Solar thermal technologies and applications	18
09	20CAE333	Design of Vibration control system	20
10	20MST322	Manufacturing of Electronic Components	21

(Group-1): **Course Code** : **20MAU13**

Course Title: NOISE VIBRATION HARSHNESS

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Fundamentals of sound:

Definition of NVH, Vehicle noise - Direct sound generation mechanism: airborne sound; Indirect sound generation mechanism: structure borne sound; Subjective response sound, Acoustic variables, basic attributes of sound such as wavelength, period, frequency; speed of sound, Decibel scale, Wave equation, types of sound fields,

Measures of sound: Sound pressure, sound intensity and sound power, Combining sources: dB arithmetic, Standing wave, Beating, Impedance, Human hearing: frequency Versus sound pressure level, Loudness: phons and sones as noise descriptors; Weighting networks, Leqand various noise metrics for road noises.

Module-2

Noise measurements and Instrumentation:

Measuring microphones, Sound level meter, time and frequency weighting, Sound spectra – Octave band analysis, Order analysis and waterfall plot, Various types of acoustic testing chambers, Sound power measurement from Sound pressure: Two- microphone probe for measuring; Sound power measurement from Sound Intensity

Module-3

Sound fields and Room Acoustics:

Characterizing sound sources; Directivity; Sound Fields; Various approaches to modelling sound sources; Transmission loss (TL) and Insertion loss (IL); Reverberation time and Acoustic Absorption Coefficient; Effects of leaks on barrier and TL of composite barriers; measurement Absorption Coefficient and Transmission loss (TL).

Vehicle Interior and Exterior noise:

Internal noise sources in vehicles such as engine noise; road noise; aerodynamic (wind) noise; brake noise; squeak, rattle and tizz noises; sound package solution to reduce the interior noise: acoustic isolation, acoustic absorption and damping material solutions; Exterior noise sources in vehicles such as air intake systems and exhaust systems; Tyre noise.

Module-4

Sources of Vehicle Vibration:

Power train and Engine vibrations; driveline vibrations; chassis and suspension vibrations; Control strategies; Human response to vehicle vibrations, concept of harshness; subjective and objective evaluation of vehicle harshness.

Vibration Isolation and Control:

Introduction; damping of vibrations; vibration isolation and absorption; design of a Vibration Absorbers, unconstrained and constrained layer damping treatment, add on dampers and stiffeners, Introduction to Active Vibration Control.

Module-5

Vibration Measurement and Instrumentation:

Definition of Modal Properties, Modal analysis theory, FE & Experimental modal analysis, Transducers and accelerometers Excitation sources Impact Excitation, Shaker excitation, Excitation signals, applications of Modal Analysis, laser based vibration measurements; analysis and presentation of vibration data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Engineering Noise Control: Theory and Practice	Bies D. A. and Hansen C. H	Spon Press, Taylor &Francis, NYUSA	2003

2	Vehicle Refinement- Controlling Noise & Road	Mathew Harrison	Elsevier Publication Ist Edition	2004
3	Theory and Problems of Mechanical Vibrations	William W. Seto	McGraw Hill International Book Co., Singapore, Illustrated Edition,	1964
4	Mechanical Vibrations	S. S. Rao	Pearson Education Inc., 5th Edition,	2010
5	Mechanical Vibrations	S. Graham Kelly	Tata McGraw Hill Publishing Co. Ltd. SI Edition	2000

(Group-1): **Course Code : 20MAU21**

Course Title: VEHICLE DYNAMICS

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Basics of Vibration:
Definitions, Modelling and Simulation, Global and Vehicle Coordinate System, Free, Forced, Un-damped and Damped Vibration, Response Analysis of Single DOF, Two DOF, Multi DOF, Magnification factor, Transmissibility, Vibration absorber, Vibration measuring instruments, Torsional vibration, Critical speed. Modal analysis.

Module-2

Tyres:
Tyre forces and moments, Tyre structure, Longitudinal and Lateral force at various slip angles, rolling resistance, tractive and cornering property of tyre. Performance of tyre on wet surface. Ride property of tyres. Magic formulae tyre model, Estimation of tyre road friction. Test on Various road surfaces. Tyre Vibration.

Braking Performance:
Basic equations, Braking forces, Brakes, Brake Proportioning, Antilock Brake system, Braking efficiency, Rear wheel lockup, Standards and Legislations, Numerical Examples

Module-3

Vertical Dynamics:
Human response to vibration, Sources of Vibration. Design, analysis and computer simulation of Passive, Semi-active and Active suspension using Quarter car, half car and full car model. Influence of suspension stiffness, suspension damping, and tyre stiffness. Control law for LQR, H-Infinite, Skyhook damping. Air suspension system and their properties.

Vehicle Aerodynamics:
Aerodynamic, Aerodynamic forces lift and drag components, Pitching, yawing, rolling moments, and Total road loads, Numerical Examples

Module-4

Steady State Handling Characteristics of Road Vehicles;
Steering Geometry, Derivation of fundamental equation governing the steady state handling behaviour of a road vehicle, Neutral Steer, Under steer and Over steer characteristics, characteristic and critical speeds, Neutral Steer Point, Static margin, Steady-State Response to Steering Input-Yaw Velocity Response, Lateral Acceleration Response, Sideslip Response and Curvature Response; Numerical Problems.

Performance Characteristics of Off-Road Vehicles:
Drawbar Performance - Drawbar Pull and Drawbar Power, Tractive Efficiency, Coefficient of Traction, Weight-to-Power Ratio for Off-Road Vehicles; Fuel Economy of Cross-country Operations Transport Productivity and Transport Efficiency, Mobility Map and Mobility Profile, Selection of Vehicle Configurations for Off-Road, Numerical Problems.

Module-5

Suspension Mechanisms:
Solid Axle Suspension, Independent Suspension, Roll Center and Roll Axis, Car Tire Relative Angles, Toe, Caster Angle, Camber, Trust Angle, Suspension Requirements and Coordinate Frames, Kinematics Requirements, Dynamic Requirements, Wheel, wheel body, and tyre Coordinate Frames, Caster Theory, Numerical examples

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Vehicle Dynamics, Theory and Applications	Reza N. Jazar	Springer Verlag. 2nd Edition,	2014

2	Theory of Ground Vehicles John Willey & Sons	J. Y. Wong	NY 4th Edition	2008
3	Pacejka Tyre and Vehicle Dynamics	Hans B	SAE 2nd Edition	2006
4	Motor Vehicle Dynamics: Modelling and Simulation World Scientific	Giancarlo Genta	Publishing Co., Singapore 3rd Edition	2017
5	Aerodynamics of Road Vehicles	Hucho W. H	SAE 4th Edition,	1998

(Group-1): **Course Code : 20MAU23**

Course Title: AUTOMOTIVE BODY ENGINEERING & SAFETY

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction:
Types of car bodies, bus bodies and commercial vehicle bodies.

Interior Ergonomics:
Introduction, Seating dimensions, Interior ergonomics, ergonomics system design, seat comfort, requirements of drivers and passenger seats, suspension seats, split frame seating, back passion reducers, dash board instruments, electronic displays, commercial vehicle cabin ergonomics, mechanical package layout, goods vehicle layout. Visibility, regulations, drivers visibility, methods of improving visibility, Window winding and seat adjustment mechanisms.

Module-2

Aerodynamics:
Basics, Vehicle drag and types, Various types of forces and moments, effects of forces and moments, various body optimization techniques for minimum drag, Principle of wind tunnel technology, flow visualization techniques, tests with scale models, aerodynamic study for heavy vehicles.

Body Materials, Trim and Body Mechanisms:
Steel sheet, timber, plastic, glass, GRP, properties of materials - Corrosion - Anticorrosion methods – Selection of

Module-3

Car body details: Types: Saloon, hatchback, convertibles, Limousine, Estate Van, racing and sports car, etc. Car body construction types – frame and unitary (monocoque), various body panels and their constructional details

Bus body details: Types: Mini bus, single and double Decker, split level and articulated bus, Bus body lay out, Floor height, Engine location, Entrance and exit location, Seating dimensions, Constructional details: Frame construction, Double skin construction, Types of metal section used, Regulations, Conventional and integral type construction

Module-4

Body Loads and Design of Vehicle Bodies:
Idealized structure-structural surface, shear panel method, symmetric and asymmetrical vertical loads in car, longitudinal loads and different loading situations.

Vehicle Layout Design:
preliminary design, Load distribution on vehicle structure, stress analysis of bus body structure under bending and torsion, stress analysis in integral bus body, Design of chassis frame, Rules and regulations for body, Recent safety measures, Testing of body.

Module-5

Vehicle Safety:
Active and passive safety, Restraint systems used in automobiles: safety belts, Head restraints, Air bags, Knee bolsters, Importance of Bumpers and their design, Types of safety glass and their requirements, Importance of Ergonomics in Automotive safety- Locations of controls.

Vehicle Structures for Crash Worthiness:
Types of crash / roll over Tests, Regulatory requirements for crash testing, Instrumentation, high speed photography, Image Analysis

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Vehicle Body Engineering Business Books Ltd	Pawloski J,	Illustrated Edition	1969

2	The automotive chassis	Reimpell J	Engineering principle 2nd Edition	1983
3	Low speed Automobile Accidents	Watts, A. J., et al	Lawyers and Judges, 3rd Edition	1996
4	An Introduction to Modern Vehicle Design	Jullian Happian	SAE Illustrated Edition	2002
5	Vehicle Body building and drawing	Braithwaite J.B.	Heinemann Educational Heinemann Educational Books Ltd., London	1967

(Group-1):	**Course Code: 20MAU242**
Course Title: VEHICLE PERFORMANCE	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction to Vehicle System:
Morphology of vehicles, General layout of passenger cars and commercial vehicle, Type of power units, arrangement of power train, Vehicle controls

Module-2

Friction and Rolling Resistance of Pneumatic Tyres:
Aerodynamics forces and moments, Relationship between tractive effort and longitudinal slip of tyres, cornering properties of tyres, Equation of motion and maximum tractive effort

Module-3

Vehicle Performance Estimation and Prediction:
Power plant characteristic and transmission related requirements, Vehicle acceleration, and max. Speed, Gradability, Drive systems comparison.

Module-4

Vehicle Transmissions:
Characteristics and features friction clutches, mechanical geared transmission lay shaft and epicyclic gearbox, Synchronizers, Fluid coupling and torque converters. Drive lines, two wheel drive, four wheel drive, braking arrangement, safety in braking, weight transfer steering, and cornering power of tyres

Module-5

Handling Characteristics of Vehicles:
Steering geometry, steady state handling characteristics, steady state response to steering input. Directional stability of vehicle. Effect of shock and vibration on human being, comfort criteria

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Theory and Practice of Mechanical Vibrations	Rao J.S. and Gupta. K	Wiley Eastern Ltd., 2nd Edition	2002
2	Theory of ground vehicle	J. Y. Wong	John Wiley and Sons Inc., New York, 1st Edition	1978
3	Steering, Suspension tyres	J. G. Giles	llife Books Lid London London1st Edition	1975
4	Automotive chassis	P. M.Heldt	Chilton Co, New York, 1st Edition	1982

(Group-1): **Course Code : 20MAU251**

Course Title: Advanced Machine Design

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction:
Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples.
Fatigue of Materials: Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features.

Module-2

Stress-Life (S-N) Approach:
S-N curves, Statistical nature of fatigue test data, General S-N behaviour, Mean stress effects, Different factors influencing S-N behaviour, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using SN approach.
Strain-Life (ε-N) approach:
Monotonic stress-strain behaviour, Strain controlled test methods, Cyclic stress strain behaviour, Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach.

Module-3

LEFM Approach:
LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation. Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean stress effects and Haigh diagrams, Notch strain analysis and the strain – life approach, Neuber's rule, Glinka's rule, applications of fracture mechanics to crack growth at notches

Module-4

Fatigue from Variable Amplitude Loading:
Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach

Module-5

Surface Failure:
Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Metal Fatigue in Engineering Ralph I	Stephens, Ali Fatemi, Robert, Henry O.Fuchs,	John Wiley, New York, 2nd Edition	2001
2	Failure of Materials in Mechanical Design	Jack. A. Collins	Design John Wiley, New York 2nd Edition	1993
3	Fatigue of Materials Cambridge University	S .Suresh	Press 2nd Edition	2006

4	Fundamentals of Metal Fatigue Analysis	Julie .A. Benantine	Prentice Hall, Illustrated Edition	1990
5	Nikki Di Mateo Fatigue and Fracture	Steven R. Lampma	ASM Hand Book Illustrated Edition	1996

(Group-1): **Course Code : 20MAU324**

Course Title: VEHICLE AERODYNAMICS & ERGONOMICS

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Fundamentals of Aerodynamics:
Scope- concept of bluff body, Generic Shapes, relevance of these shapes to ground vehicles. Pressure drag and viscous drag, flow phenomenon related to vehicles- External and Internal flows, Resistance to vehicle motion, flow field around car, aerodynamic development of cars, Optimization of car bodies for lower drag

Module-2

Stability, Safety and Comfort:
The origin of forces and moments- effects- vehicle dynamics, under side wind forces and moment coefficients- safety limits, design stage measures, important factors affecting aerodynamics like rear slant, cross winds, engine cooling air flow, under body flow, wheel rotation, air flow around individual components, high performance vehicles, very long

Module-3

Wind Tunnels and Test Techniques:
Principles of wind technology- limitations of simulation- simulation based optimization of geometrics, drag reduction technologies- surface shaping, scaled models. Wind tunnel experiments- measurement of pressure coefficients, drag force, wind tunnel limitations and corrections- boundary layer control, wind tunnel blockage, climatic tunnels, measuring equipment and transducers-pressure measurement, velocity measurement, flow visualization techniques, Wind noise measurement.

Module-4

Application of CFD:
Methods to solve Navier – stoke equations, forces acting on fluid element, compressibility effect in a flow field, inviscid flow, governing equations, irritation flow field and consequences, potential flow, boundary layer methods. Important requirements of CFD solvers, Geometric/ Dynamic similarity, robust flow solver. Turbulence models, Numerical modelling of fluid flow around vehicle body.

Module-5

Aerodynamic Design:
Development and simulation of cars, buses, trucks, surface motion, surface permeability, mass addition, energizing flow around the vehicle

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Aerodynamics of Road vehicles	W. H. Hucho	Butterworth and Co Ist Edition	1987
2	Boundary Layer Theory	Schlichting H	Mc. Graw Hill, New York 7th Edition	1975
3	Low speed Wind tunnel Testing	Pope A	John Wiley and Sons, New York 3 rd Edition	1999

4	Society of Automotive Engineers	SAE	SAE Vehicle Aerodynamics Packet Society of Automotive Engineers, Edition	2006

(Group-1): **Course Code : 20MCM11**

Course Title: NUMERICAL METHODS FOR ENGINEERS

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Approximations and round off errors: Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Mathematical modelling and Engineering problem solving: Simple mathematical model.

Roots of Equations: Bracketing methods-Graphical method, Bisection method, False position method, Newton-Raphson method, Secant Method. Multiple roots, Simple fixed point iteration. MATLAB or Sci Lab session for solving equations using Graphical method, Bisection method, False position method and Newton Raphson method.

Module-2

Roots of Polynomial-Polynomials in Engineering and Science, Muller's method, Numerical Differentiation and Numerical Integration: Newton – Cotes and Guass Quadrature Integration formulae, Integration of Equations, Romberg integration, Numerical Differentiation Applied to Engineering problems, High Accuracy differentiation formulae. MATLAB or Sci Lab session for Numerical differentiation and Numerical Integration**.**

Module-3

System of Linear Algebraic Equations and Eigen Value Problems: Introduction, Direct methods, Cramer's Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, error Analysis for direct methods, Iteration Methods. MATLAB or Sci Lab session for solving system of equations using Cramer's Rule, Gauss elimination method and Gauss-Jordan method.

Module-4

Eigen values and Eigen Vectors: Bounds on Eigen Values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Householder's method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method, Inverse power method. MATLAB or Sci Lab session for finding Eigen values and Eigen vectors of a square matrix.

Module-5

Linear Transformation: Introduction to Linear Transformation, The matrix of Linear Transformation, Linear Models in Science and Engineering. Orthogonality and Least Squares: Inner product, length and Orthogonality, orthogonal sets. Model some simple mathematical models of physical Applications and Find the roots of polynomials in Science and Engineering problems

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Introductory Methods of Numerical Analysis,	S.S.Sastry,	PHI	2005.
2	Numerical Methods for Engineers,	Steven C. Chapra, Raymond P.Canale	Tata Mcgraw Hill, 4th Ed	2002.
3	Numerical methods for Scientific and engg computation	M K Jain, S.R.K Iyengar, R K. Jain,	New Age International,	2003
4	Fundamentals of Engineering Numerical	Pervez Moin,	Cambridge	2010
5	Linear Algebra and its applications	David. C. Lay,	3rd edition, Pearson Education	2002

6	A Guide to MATLAB for Beginners and Experienced Users	Brian R Hunt, Ronald L Lipsman, Jonathan M Rosenberg	Cambridge University Press.	

(Group-1): **Course Code : 20MTP251**

Course Title: SOLAR THERMAL TECHNOLOGIES AND APPLICATIONS

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Solar Radiation: Location on earth, celestial sphere, horizon and equatorial system, Instruments for measuring solar radiation and sunshine, description of the various angles depicting the relation between sun and earth, coordinates transformation, solar time, obliquity and declination of the sun, apparent motion of the sun, sun rise and sun set time, east west time, analysis of the direct daily solar radiation on any arbitrarily located surface.

Module-2

Flat Plate Collectors: Performance analysis, transmissivity of the cover system, overall loss coefficient and heat transfer correlations, collector efficiency factor, collector heat removal factor, effects of various parameters on the performance. Evacuated Tube Collectors Principle of working, advantages of ETC over FPC, Types of evacuated tubes. Design aspects of solar plate collectors.

Module-3

Concentrating Collectors: Types, description of cylindrical parabolic collector, orientation and tracking modes, performance analysis, parametric study of collector performance in different modes of operation, compound parabolic collector geometry, tracking requirements, parabolic dish collector.

Module-4

Thermal Energy Storage: Introduction, sensible heat storage: liquids, solids, analysis of liquid storage tank in well mixed condition and thermal stratification, analysis of packed-bed storage, latent heat storage, thermo chemical storage.

Module-5

Applications: Water heating systems (Natural and Forced), Industrial process heating system, Active and passive space heating, Solar absorption refrigeration, Power generation (Low Temperature, Medium Temperature, High Temperature), Distillation, Drying, Cooking, Solar Pond. Recent advancement in materials and systems for thermal energy storage systems.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	"Solar Energy- Principles of Thermal Collection and Storage",	S.P. Sukhatme, J K Nayak	Tata McGraw Hill Company Ltd., New Delhi.	
2	"Non- Conventional Energy Sources"	G. D. Rai.,	Khanna Publishers, New Delhi	
3	Solar Thermal Engineering Systems,	G.N. Tiwari and S. Suneja,	Narosa Publishers.	
4	"Non-Conventional Energy Resources",	Khan, B.H.,	Tata McGraw Hill, 2nd Edition, New Delhi.	
5	Recent Advancements in Materials and Systems for Thermal Energy Storage,	Dott. Andrea Frazzica, Prof. Luisa F. Cabeza,	ISBN 978-3-319-96639-7	

(Group-1): **Course Code : 20CAE333**

Course Title: DESIGN OF VIBRATION CONTROL SYSTEMS

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Review of Mechanical Vibrations Basic concepts: free vibration of single degree of freedom Systems with and without damping, forced vibration of single DOF-systems, Natural frequency.
Vibration Control: Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, vibration isolation, Dynamic vibration absorbers, and Vibration dampers.

Module-2

Transient Vibration of single Degree of freedom systems: Impulse excitations, arbitrary excitation, Laplace transform formulation, Pulse excitation and rise-time, Shock response spectrum, Shock isolation.
Random Vibrations: Random phenomena Time averaging and expected value, Frequency Response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms and

Module-3

Vibration Measurement and applications: Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis.
Modal analysis &Condition Monitoring: Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis.

Module-4

Vibration and Noise Control : Basics Of Noise, Introduction, amplitude, frequency, wavelength and sound pressure lavel, addition, subtraction and averaging decibel; levels, noise dose lavel, legislation, measurement and analysis of noise, measurement environment, equipment, frequency analysis tracking analysis sound quality analysis. Introduction to Automotive noise sources, Engine over-all noise lavels.

Module-5

Continuous Systems: Vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	"Mechanical Vibrations"	S. S. Rao,	Pearson Education, 4th edition.	
2	" Fundamentals of Mechanical Vibration"	S. Graham Kelly	McGraw-Hill	2000
3	Theory of Vibration with Application,	William T. Thomson, Marie Dillon		
4	" Mechanical Vibrations", Schaum' s Outlines,	S. Graham Kelly	Tata McGraw Hill	2007
5	" Vibrations and Acoustics – Measurements and signal analysis"	C Sujatha	Tata McGraw Hill	2010

(Group-1):	**Course Code : 20MST322**
Course Title: MANUFACTURING OF ELECTRONIC COMPONENTS	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction: Important components of Electronic products. Types of Semiconductor materials and properties and their properties. Manufacturing ICs: The functions of Ics manufacturing of diodes. Production of a single Ic component classification of Ic Architecture.

Module-2

Manufacturing of Silicon Water: fabrication of IC on silicon wafers Fabrication of IC on Silicon wafers. Diffusion doping, Ion Implantation, Rapid thermal processing- Thermal oxidation Monolithic processing, Lithography, Photolithography, Etching processes. Thin film Deposition: Physical vapour Deposition, chemical vapor deposition, Epitoxial growth, IC component interconnection, IC yield and economics.

Module-3

IC packing. Types of packaging process. Printed Circuit Boards: Typical substrate (base) Materials and selection of substrate materials, Types of PCBs. Methods of manufacturing Of PCBs.

Module-4

Electronic Assembly: General Description of Electronic Assembly detailed study of sequences of operation for through-hole and surface mount process.

Module-5

Micro Electro-Mechanical systems Introduction to micro sensors MEMS, micro machines fundamentals of Silicon micro machining- Bulk & surface micromachining. Micro stereo lithography. Micro sensors: Types & brief description and applications of Thermal and Smart sensors & MEMS Devices.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Materials and processes in manufacturing,	E. Paul Degarmo, IT Black and Ronald A	Kohser Wiley student Edition	2004
2	Electronics materials handbook Vol 1		Minger ML Packing ASM	
3	RF: Semiconductor fundamentals.	Addisor -Wisley	Reading mass	1998.
4	Electronic materials & processes handbook, Jarger RC: introduction to Microelectronic Fabrication. Addision Wesley 1990	CA Harper & RM Sampson	2nd Edition McGraw Hill	1994
5	The science and Engineering of microelectronics	Cambell	Oxford University press	2001.

Ph.D Coursework Courses under Group - 2			
Sl No	**Course Code**	**Course Name**	**Page**
1	20MAU12	Advances in Automotive engines & systems	23
2	20MAU15	Alternative fuels, engine emission & emission control norms	25
3	20MAU244	Engine management systems	27
4	20MAU252	SI and CI Engine Processes Simulation	29
5	20MAU254	Design of Heat Transfer Equipment	30
6	20MTP323	Design and Analysis of thermal system	32
7	20MCM333	Virtual Instrumentation	33
8	20MSE332	Agile manufacturing	34
9	20MTE321	Advanced moulding Techniques	35
10	20MMD23	Tribology and Bearing Design	36

(Group-2): **Course Code** : **20MAU12**

Course Code: **ADVANCES IN AUTOMOTIVE ENGINES & SYSTEMS**

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Fuel Supply and Injection Systems:

SI Engine: Types and Components of fuel injection systems, Continuous injection system, Timed injection system, Electronic Fuel Injection systems (EFIs), Merits and Demerits electronic , Multi point fuel injection system(MPFI), Functional divisions of MPFI system, Electronic control system, Injection timing, Group gasoline injection system

C.I. Engines: Fuel injection pump systems- Types, constructional features and operation, Factors influencing fuel spray atomization, penetration and dispersion of diesel, Fuel Injection Pumps (inline, rotary), Electronic diesel injection system, Electronic diesel injection control.

Module-2

Ignition system:

Energy requirements for ignition, Requirement of an ignition system, Battery ignition system, its operation and limitations, Dwell angle, 12V ignition system, 42 V ignition system, Magneto ignition system,

Modern ignition systems: Transistorized (TCI) and Capacitive Discharge (CDI), Firing order, Ignition timing and engine parameters, Spark advance mechanism, Ignition timing and exhaust emissions.

Module-3

Cooling and Lubrication System:

Cooling System: Necessity, variation of gas temperature, Areas of heat flow, heat transfer, piston and cylinder temperature, Heat rejected to coolant, quantity of water required, cooling system, air cooling, water cooling thermodynamics of forced circulation, thermostats, pressurized water cooling, regenerative cooling, comparison of air and water cooling, radiators types, cooling fan – power requirement, antifreeze solution.

Lubrication System: Lubricants, lubricating systems, Lubrication of piston rings, bearings, oil consumption, Oil cooling. Heat transfer coefficients, liquid and air cooled engines, coolants, additives and lubricity improvers, oil filters, pumps, and crankcase ventilation – types

Module-4

Engine Management System: Combined ignition and fuel management systems, Digital control techniques. Complete vehicle control systems. Artificial intelligence and engine management, Exhaust emission control in SI and CI engines Techniques.

Module-5

Supercharger and Turbo charger

Supercharger, Working Principle, Effect of Super charging, Types and Methods of Super charging, Turbo Charger, Working Principle , Turbo-lag,

Recent Developments in Automotive Engines:

VVT, V-TEC i-VTEC and IDTEC.ATFT, CRDI system- working Principle, Advantages and Effect of CRDI on emission reductions, Hybrid vehicles and fuel cells.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Internal Combustion Engine Fundamentals	John B. Heywood	McGraw, Hill Book Company	1988
2	Ramalingam, Introduction to Internal Combustion Engines	Dr. K. K.	Scitech Publication	2004
3	Automotive Electrical and Electronics	Tom Denton	SAE Publications	2000

4	Advanced Engine Technology	Heinz Heisler	SAE Publications	1995
5	Internal Combustion Engine Hand Book	Richard Van Basshuysen	Fred Schaefer, SAE	2004

(Group-2): **Course Code: 20MAU15**

Course Title: ALTERNATIVE FUELS, ENGINE EMISSION & EMISSION CONTROL NORMS

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction:

Types of energy sources, their availability, need of alternative energy sources, Non-conventional energy sources, Classification of alternative fuels, Scenario of conventional auto fuels, fuel quality aspects related to emission. Technological up gradation required, business driving factors for alternative fuels. Implementation barriers for alternative fuels.

Gaseous Alternative Fuels:

Hydrogen:

Introduction, properties and production of hydrogen. Storage, Advantages and disadvantages of hydrogen as fuel for S. I. and C. I. engines. Hazards and safety systems for hydrogen, hydrogen combustion. Performance and emission of from hydrogen.

Other Gaseous Fuels:

Properties, production, advantages and disadvantages of LPG, CNG, Methanol and Ethanol and their blends as Fuel for SI and CI engine

Module-2

Bio-Diesel:

Straight vegetable oil, Biodiesel-Production of Bio-Diesel, Bio-Diesel as Fuel for CI engine, Performance and emission of bio diesel.

Biogas or Bio-methane:

History, properties and production of Biogas, classification of biogas plants, biogas storage and dispensing system. Advantages of biogas, hazards and emissions of biogas.

Reformulated conventional fuels:

Introduction. Production of coal water slurry. Properties, as an engine fuel, emissions of CWS. RFG, Emulsified fuels. Hydrogen-enriched gasoline. Future Alternative Fuels, PMF, Ammonia, Liquid-Nitrogen.

Module-3

Source of Emission from Automobiles:

Sources of Air Pollution. Various emissions from Automobiles- Formation-Effects of pollutants on environment and human beings.

S. I. Engine Emissions and its Control:

Emission formation in SI Engines- Carbon monoxide & Carbon dioxide -Unburned hydrocarbon, NOx, Smoke- Effects of design and operating variable son emission formation- controlling of pollutants - Catalytic converters, Charcoal Canister, CCS, Positive Crank case ventilation system, Secondary air injection, thermal reactor, Laser Assisted Combustion, etc.

Module-4

C. I. Engine Emission and its Control:

Formation of White, Blue, and Black Smoke, NOx, soot, sulphur particulate and Intermediate Compounds - Physical and Chemical delay- Significance Effect of operating variables on Emission formation- Fumigation, Split injection, Add Blue, Catalytic Coating, EGR, HCCI, Particulate Traps, SCR.

Influence of Fuel Properties on Emission and Effect of Air Pollution:

Effect of petrol, Diesel Fuel, Alternative Fuels and lubricants on emissions, Effect of air pollution on Human Health, Effect of air pollution on animals, Effect of air pollution on plants

Module-5

Test Procedures , Emission Measurements:

Constant Volume Sampling I and 3 (CVS-1&CVS-3) Systems, Sampling Procedures- Chassis dyno- Seven mode and thirteen mode cycles for Emission Sampling-Sampling problems -Emission analyzers - NDIR, FID, Chemi - luminescent, Smoke meters.

Emission control Norms:

Emission norms – Euro: Euro 5 and Euro 6 Norms , Relative comparison ; & Bharat norm: Bharat Stage V and Bharat stage VI, Relative comparison of both

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.

- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Alternative Fuels- JAICO	S.S. Thipse	Publishing House New Delhi 2nd Edition	2019
2	Non-Conventional Energy Sources	G. D. Rai	Khanna Publishing New Delhi 6thEdition	2019
3	Internal combustion Engines	V. Ganesan	Tata McGraw Hill Book Co, Eighth Reprint, 4th Edition	2019
4	Emission from Combustion Engine and their control	D. J. Patterson and N. A. Henin	Anna Arbor Science Publication, 2nd Edition	1981
5	Automotive Emission Control	Crouse and Anglin	McGraw Hill Company., New York ,2nd Edition	1977

(Group-2): **Course Code: 20MAU244**

Course Title: ENGINE MANAGEMENT SYSTEMS

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Engine Input Sensors : Coolant & Intake Temperature, Crankshaft Position, Camshaft Position, Manifold Absolute Pressure, Throttle Position, Oxygen, Air/Fuel Ratio, Knock Speed & Distance, Battery & Switches
Output Devices: Relays, Injector Sequencing & Management, Ignition Operation, Idle Air Control, EGR, EVAP, Waste gate Solenoids, Torque Converter & Speed Control, Malfunction Indicator Light

Module-2

Speed Density/Mass Air Flow Fuel Management Strategies: Key ON Mode, Crank Mode, Open & Closed Loop, Wide-Open Throttle, Adaptive Memory Cells, Cruise &Deceleration, Wide-Open Throttle, Key OFF Mode
Fuel Injection Systems: Electronic Fuel Systems, Computer Self-Diagnostic Circuits, Electronic Throttle Actuator Control Systems, Fuel Control, Fuel Supply System Control, Injection System Inspection and Maintenance

Module-3

Engine Diagnostic Procedures: Fuel System testing, On Board Diagnostics, Monitored & Non Monitored Circuits, Diagnostic Trouble Codes
Digital Engine Control System: Open loop and close loop control system, engine cooling and warm up control, idle speed control, acceleration and full load enrichment, deceleration fuel cut-off. Fuel control maps, open loop control of fuel injection and closed loop lambda control exhaust emission control, on-board diagnostics, diagnostics, future automotive electronic systems, Electronic dash board instruments – Onboard diagnosis

Module-4

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

Module-5

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

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Automotive Fuel and Emissions Control Systems	Halderman, J. & Linder, J	Saddle River, NJ: Pearson Education 3rd Edition	2012
2	Diagnosis &Troubleshooting of Automotive Electrical	Halderman, J. D	Electronic, &Computer Systems, Upper Saddle River, NJ Pearson	2011
3	Diesel Engine Management	Robert Bosch	SAE Publications 3rd Edition	2004

4	Understanding Automotive Electronics Newnes	Wiliam B. Ribbens	Butterworth – Heinemann 5th Edition	2001
5	Automobile Electrical & Electronic Equipments	Young, Griffitns	Butterworths, London 6th Edition	1980

(Group-2): **Course Code: 20MAU252**

Course Title: SI AND CI ENGINE PROCESSES SIMULATION

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Principle Of Computer Modelling and Simulation:
Monte Carlo simulation, Nature of computer modelling and simulation, advantages of simulation, limitations of simulation, and areas of application.

System and Environment:
Components of system-discrete and continuous systems. Model system-a variety of modelling approaches.

Module-2

Design and Evaluation of Simulation Experiments:
Variance reduction techniques-antithetic variables- variables verification and validation of simulation models

Module-3

S.I. Engine Simulation and Two Stroke Engine:
Simulation of Otto cycle at full throttle, part throttles and supercharged conditions. Progressive combustion, Exhaust and intake process analysis. Two Stroke Engine Simulation-Engine and Porting Geometry, Gas Flow, Scavenging.

Module-4

C.I. Engine Simulation:
Simulation of ideal Diesel cycle and Diesel cycle at full throttle, part throttle and supercharged conditions. Zero dimensional combustion model, Progressive combustion, Exhaust and intake process analysis.

Module-5

Simulation Exercises:
Case studies of Simulation for 2 stoke and 4 stroke engine. Simulation exercises using computers – MATLAB/SimuLink, Pro-E / ICEM, CFD Analysis, FE Analysis procedures, Advantages of FEA, Simple Exercise using MSC Nastran.

Multi-body Simulation Exercises:
Simple Multi-body Suspension, Four Bar mechanisms, Handling Analysis of simple Bogie using MSC Adams.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Simulation of Spark Ignition Engine Processes	V. Ganesan	Universities Press 1st Edition	1996
2	Computer Simulation of Compression Ignition Engine	V. Ganesan	Universities Press1st Edition	1996
3	Combustion Modelling in Reciprocating Engines	J. N. Mattavi and C. A. Amann	Plenum Press 1st Edition	1980
4	The Thermodynamics and Gas Dynamics of Clarendon	Horlock&Winterbone	Press Illustrated edition	1982-1986
5	Internal Combustion Engine Modelling Hemisphere	J. I. Ramos	Publishing Corporation 1st Edition	1989

(Group-2): **Course Code : 20MAU254**

Course Title: DESIGN OF HEAT TRANSFER EQUIPMENT

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction to Heat Exchangers: Definition, Applications, Various methods of classification of heat exchangers Introduction to Heat Exchangers: Definition, Applications, Various methods of classification of heat exchangers with examples, Governing Equation for heat exchangers: Derivation from steady-state steady-flow considerations.

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

Module-2

Concept of Logarithmic Mean Temperature Difference: Expression for single-pass parallel-flow and single-pass counter flow heat exchangers – Derivation from first principles, Special Cases, LMTD for a single-pass cross-flow heat exchanger – Nusselt‟s approach, Chart solutions of Bowman et al. pertaining to LMTD analysis for various kinds of heat exchangers, Numerical Problems,

Arithmetic Mean Temperature Difference [AMTD], Relation between AMTD and LMTD, Logical Contrast between AMTD and LMTD, LMTD of a single-pass heat exchanger with linearly varying overall heat transfer

Module-3

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

Module-4

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

Module-5

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

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Compact Heat Exchanger	Kays, W. M. and London, A. L	McGraw – Hill, New York 2nd Edition	
2	Kern Process Heat Transfer Echo Point Books	Donald Q.	Media Illustrated, reprint	,2019
3	Fundamentals of Heat and Mass Transfer	Incropera, F. P. and De Witt, D. P	John Wiley and Sons, New York 7th Edition	2013
4	McGraw Hill education Heat and Mass Transfer	Yunus A Cengel; Afshin J. Ghajar	Fundamentals and Applications (SIE) 5th Edition	2017

5	McGraw Hill education Heat Transfer	J Holman, Souvik Bhattacharyya	SIE 10th Edition	2017

(Group-2):	**Course Code : 20MTP323**
Course Title: DESIGN & ANALYSIS OF THERMAL SYSTEMS	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Thermal Systems: Characteristics- formulation of design problem - Steps in the design process - Modeling of thermal systems – importance - Types of models – Mathematical Modeling, Exponential forms- Method of least squares - Counter flow heat exchanger, Evaporators and Condensers, Effectiveness, NTU, Pressure drop and pumping power.

Module-2

Design of piping and pump systems:- Head loss representation ;Piping networks; Hardy - Cross method Generalized Hardy – Cross analysis; Pump testing methods; Cavitation considerations; Dimensional analysis of pumps; piping system design practice.

Module-3

Unconstrained Optimization Techniques: Univariate, Conjugate Gradient Method and Variable Metric Method. **Constrained Optimization Techniques:** Characteristics of a constrained problem; Direct Method of feasible directions; Indirect Method of interior and exterior penalty functions.

Module-4

Thermo-economic analysis and evaluation: Fundamentals of thermo-economics, Thermo-economic variables for component evaluation; thermo-economic evaluation; additional costing considerations.

Module-5

Thermo-economic optimization: Introduction; optimization of heat exchanger networks; analytical and numerical optimization techniques; design optimization for the co-generation system- a case study; thermo-economic optimization of complex systems.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Thermal Design & Optimization	Bejan, A., et al.	John Wiley	1996
2	Analysis & Design of Thermal Systems	Hodge, B.K 2nd edition	Prentice Hall	1990
3	Design of Thermal Systems -.,	Boehm, R.F	John Wiley,	1987.
4	Design of Thermal Systems -,	Stoecker, W.F.	McGraw-Hill	

(Group-2): **Course Code : 20MCM333**

Course Title: VIRTUAL INSTRUMENTATION

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Virtual Instrumentation: An introduction

Historical perspective, advantages, block diagram and architecture of a virtual instrument, data-flow techniques, graphical programming in data flow, and comparison with conventional programming. Development of Virtual Instrument using GUI, Real-time systems.

Module-2

VI programming techniques:

VIs and sub-VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, string and file I/O, Instrument Drivers, Publishing measurement data in the web.

Module-3

Data acquisition basics:

Introduction to data acquisition on PC, Sampling fundamentals, Input/output techniques and buses. ADC, DAC, Digital I/O, counters and timers, DMA, Software and hardware installation, Calibration, Resolution, Data acquisition interface requirements.

Module-4

VI Interface requirements:

Common Instrument Interfaces: Current loop, RS 232C/ RS485, GPIB. Bus Interfaces: USB, PCMCIA, VXI, SCSI, PCI, PXI, Firewire. PXI system controllers, Ethernet control of PXI. Networking basics for office & Industrial applications, VISA and IVI.

Module-5

VI toolsets:

Distributed I/O modules. Application of Virtual Instrumentation: Instrument Control, Development of process database management system, Simulation of systems using VI, Development of Control system, Industrial Communication, Image acquisition and processing, Motion control

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Lab VIEW Graphical Programming, ,	Gary Johnson, Second edition,	McGraw Hill, New York	1997.
2	Lab VIEW based Advanced Instrumentation Systems,	S. Sumathi and P. Surekha,	Spinger	
3	PC Interfacing for Data Acquisition and Process Control	Gupta S. and Gupta J.P	Instrument society of America	1994
4	PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control	Kevin James, WEB RESOURCES: www.ni.com	Newnes	2000
5	Lab VIEW for everyone	Lisa K. wells & Jeffrey	Travis Prentice Hall, New Jersey	1997
6	PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control	Kevin James	Newnes	2000

(Group-2): **Course Code: 20MSE 332**

Course Title: AGILE MANUFACTURING

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Agile Manufacturing: Definition, business need, conceptual frame work, characteristics, generic features. Four Core concepts: Strategy driven approach integrating organization, people technology, inter disciplinary design methodology.

Module-2

Developing Agile Manufacturing: Enterprise design, System concepts as the basic manufacturing theory-joint technical & Organizational design and a model for the design of agile manufacturing enterprise. Enterprise design process insights into design processes, what is interdisciplinary design, main issues, simple design example. Integration of Product /Process Development: Principles, Robust design approach, Approaches to enhance ability in manufacturing, Role of QFD, Managing people in Agile organization, Approaches

Module-3

Application of IT/IS Concepts In Agile Manufacturing: Strategies, Management of complexities and information. flow, approaches, applications of multimedia to improve agility in manufacturing, system concepts. Agile Supply Chain Management: Principles, IT/IS concepts in supply chain management, enterprise integration and management in agile manufacturing, concepts, Agility, Adaptability and learners – comparison of concept

Module-4

Computer Control Of Agile Manufacturing: CAPP for Agile Manufacturing, Aggregate capacity planning and production line design / redesign in Agile manufacturing, Cellular manufacturing, concepts, and examples. Corporate Knowledge Management In Agile Manufacturing: Strategies, strategic options in Agile manufacturing, Role of standards.

Module-5

Design of Skill & Knowledge: Enhancing technology for Machine tool system, Resumption of design requirement geometry, definition, methods, decision support for selection of cutting parameters, design enhancements, parametric approach only.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Agile Manufacturing	Forging Mew Frontiers', Poul T	Amagow Co. UK, ISBN-0-	1994
2	''Agile Manufacturing"	A Gunasekaran, the 21 Century Competitive strategy, ISBN -13 978-0-08-04 3567-1	Elsevier Press	2001
3	O Levine Transitions to Agile Manufacturing,	Joseph C Moutigomery and Lawrence	ASQC quality press, Milwaukee. Wisconsin, USA,	1996.
4	Agile Development for Mass Customization,	David M Anderson and B Joseph Pine,	Irwin Professional Publishing, Chicago, USA	1997.

(Group-2):	**Course Code : 20MTE321**
Course Title: ADVANCED MOULDING TECHNIQUES	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Injection Moulding Technology: Microprocessor control injection moulding machine, close loop control, open loop control, CNC control, multi color injection moulding, rotary injection moulding, structural foam moulding, sandwich injection moulding**.**

Metal injection moulding: contact injection moulding, moulding of cellular product like EPS, steam chest moulding, future trends in injection moulding like external & internal inter locking alignment of large moulds, processing of specialty polymers.

Module-2

Extrusion: General consideration during extrusion process like specific heat, latent heat, internal conductivity, shape & size of granular hygroscopic nature over temperature, effect of flow property like relaxation time & defects like shark skin, elastic turbulence, influence of TG, TM & crystal growth rate, cooling rate, impact strength, manufacturing of woven sacks etc. co extrusion, co extruded pipe, muilt layer pipe, foam pipe, biaxial oriented pipe.

Module-3

Lamination: Lamination by extrusion coating, twin screw extrusion, co-rotating& counter rotating, feeding mechanism in twin screw extruder, roll of side feed injection feeder, principles of compounding, mixing mechanism etc**.**

PTFE Moulding: Processing techniques used for PTFE, Material consideration, sintering, Ram extrusion, and Paste extrusion, lso statistic. Moulding and skewing technique for PTFE processing.

Module-4

Blow Moulding: Micro processor / CNC controlled blow moulding machine, injection stretch blow moulding of PET, precut moulding, multi layer blow moulding, Parission programming.

Reaction Injection Moulding (RIM): RIM of Polyurethane, material for RIM, liquid RIM & its advantages over conventional injection moulding, RRIM**.**

Module-5

Advancement in Other Processing Technique: New techniques like Resin transfer moulding, Pultrusion. Filament winding, multi layer rotation moulding, Electro plating and printings, Centrifugal casting, Shrink film, Clink film.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Injection Moulding	Rubin	Wiley India Pvt Ltd	2013
2	Extrusion	Berln.		
3	Injection Mold	Glavin & Denton		
4	Extrusion Die Design	M. V.Joshi		
5	Polymer Chemistry	Gowriker.		

(Group-2): **Course Code : 20MMD23**

Course Title:TRIBOLOGY AND BEARING DESIGN

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction to Tribology: Introduction, Friction, Wear, Wear Characterization, Regimes of lubrication Classification of contacts, lubrication theories, Effect of pressure and temperature on viscosity. Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen's Poiseuille's theory, viscometers. Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems.

Module-2

Hydrodynamic Lubrication: Pressure development mechanism. Converging and diverging films and pressure induced flow, Reynold's equation in two dimensions with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of center of pressure, effect of end leakage on performance, Numerical problems

Journal Bearings: Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Somerfield number and its significance, short and partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems.

Module-3

Hydrostatic Bearings: Hydrostatic thrust bearings , hydrostatic circular pad, annular pad, rectangular pad bearings, types of flow restrictors, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems, and hydrostatic journal bearings.

EHL Contacts: Introduction to Elasto - hydrodynamic lubricated bearings. Introduction to 'EHL' constant. Grubin type solution.

Module-4

Antifriction bearings: Advantages, selection, nominal life, static and dynamic load earing capacity, probability of survival, equivalent load, cubic mean load, bearing Mountings.

Porous Bearings: Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings, Equations for porous bearings and working principal, Fretting phenomenon and its stages.

Module-5

Magnetic Bearings: Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principal. Advantages and disadvantages of magnetic bearings, Electrical analogy, Magneto-hydrodynamic bearings.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	"Introduction to Tribology of Bearing"	Mujamdar.B.C	Wheeler Publishing, New	2001
2	"Lubrication of Bearings - Theoretical principles and design"	Radzimovsky	Oxford press Company	2000
3	"Theory and practice of Lubrication for Engineers"	Dudley D. Fulier	New York Company	1998
4	"Principles and applications of Tribology"	Moore	Pergamon press	1975
5	"Theory of hydrodynamic lubrication"	Oscar Pinkus, Beno Sternlicht	McGraw-Hill	1961
6	"Engineering Tribology"	G W Stachowiak, A W Batchelor	Elsevier publication	1993

7	Hydrostatic and hybrid bearings		Butterworth	1983
8	Hydrostatic bearings for machine tools and similar applications	F. M. Stansfield	Machinery Publishing	1970

Ph.D Coursework Courses under Group - 3			
SlNo	**Course Code**	**Course Name**	**Page**
1	20MAU11	Advanced Mathematical Methods in Engineering	39
2	20MAU253	Computational fluid dynamics	42
3	20MAU333	Finite Element Method	44
4	20MTP332	Non conventional Energy Resources	46
5	20MTP252	Modelling and Simulation of thermal system	47
6	20MMD251	Automobile system Design	48
7	20MST244	Advances in Material and Processing	49
8	20CAE241	CIM and Robotics for automation	50
9	20MTP14	Combustion Thermodynamics	52
10	20MPM321	Rapid Prototyping	

(Group-3):	**Course Code : 20MAU11**
Course Title: ADVANCED MATHEMATICAL METHODS IN ENGINEERING	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Errors and Simple Mathematical modelling: Error definition, round off errors and truncation errors. Mathematical modelling and Engineering problem solving: Simple mathematical model, Conservation Laws of Engineering. Engineering Applications on: Deflection of Beams, Whirling of shafts, Terminal velocity of a freely falling body.

Module-2

Roots of Equations by Numerical Methods: Newton- Raphson method, Horner's Method. Muller's method ,Barstow's (or Lin's method) , Graeffe's roots squaring method

Module-3

Ordinary Differential Equations: Solving ODE"s using: Picard's method, Runge-Kutta fourth order, Runge-Kutta Fehlberg method, Stiffness of ODE using shooting method, Boundary value problems.

Module-4

Partial Differential Equations: Classification of second order Partial Differential Equations. Solution of One dimensional wave equation,(Schmidt`s explicit formula), One dimensional heat equation by Schmidt method, Crank- Nicholson method, and Du Fort-Frankel method

Module-5

Sampling Theory: Testing of hypothesis using t and χ^2 test, Goodness of fit, F-test, Analysis of Variance: One – way with/without interactions, problems related to ANOVA, Design of experiments, RBD

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Numerical methods for Scientific and Engineering computation,	M K Jain, S.R.K Iyengar, R K. Jain,	New Age International,	2003
2	Higher Engineering Mathematics,	B.S. Grewal	Khanna Publishers, 44th Ed.	2017
3	Numerical Methods for Engineers	Steven C Chapra and Raymond P Canale	7th Ed., McGraw-Hill Edition	2015.
4	Probability and Statistics in Engineering,	William W.H., Douglas C.M., David M.G. and Connie M.B.	4th Edition, Willey Student	2008
5	Numerical Methods in Engineering and Science.	Dr. B.S. Grewal.	Khanna Publishers	1999.
6	Introduction to Partial Differential Equations	K Shankar Rao.	Prentice - Hall of India Pvt. Ltd.	1995
7	Advanced Engineering Mathematics	C. Ray Wylie and Louis C Barrett.	6th edition, McGraw-Hill	1995.

(Group-3):	**Course Code : 20MAU253**
Course Title: COMPUTATIONAL FLUID DYNAMICS	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Programming fundamentals, MATLAB programming, Numerical Methods
Governing Equations: Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for in viscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD

Module-2

Partial differential equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behaviour of Hyperbolic, Parabolic and Elliptic equations.
Basic aspects of discretization: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, Uniform and unequally spaced grid points

Module-3

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

Module-4

Elliptic equations: Finite difference formulation, solution algorithms: Jacobi-iteration method, Gauss-Siedel iteration method, point- and line-successive over-relaxation methods, alternative direction implicit methods.
Hyperbolic equations: Explicit and implicit finite difference formulations, splitting methods, multi-step methods, applications to linear and nonlinear problems, linear damping, flux corrected transport, monotone and total variation diminishing schemes

Module-5

Stability analysis: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, Artificial dissipation and dispersion.
Grid generation: Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Computational Fluid Dynamics	Anderson, J.D	McGraw-Hill Book Company, 2nd Edition	2017
2	S.T Computational Fluid Dynamics	Hoffman, K.A., and Chiang	I, II and III, Engineering Education System, Kansas, USA 2nd Edition	2000
3	Computational Fluid Dynamics	Chung, T.J	Cambridge University Press 2nd Edition	2014

4	An Introduction to Computational Fluid Dynamics	Versteeg, H.K. and MalalasekaraW	Pearson Education 2nd Edition	2010

(Group-3): **Course Code : 20MAU333**

Course Title: FINITE ELEMENT METHOD

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction to Finite Element Methods:
Engineering analysis, History, advantages and disadvantages, classification, basic concepts, convergence criteria. Role of finite element analysis in computer aided design, mathematical preliminaries, and differential equation formulation. Variational formulations, weighted residual methods

Module-2

One Dimensional Elements:
Analysis of bars and trusses, basic equations and Potential Energy functional. 1D Bar Element, Admissible displacement function, strain matrix, stress recovery, Element equation, stiffness matrix. Consistent nodal force vectors: Body force, initial strain, assembly procedure, Boundary and constraint conditions, single point constraint, multi point constraint, truss element , shape functions for higher order elements, C0, C-1 elements

Module-3

Two Dimensional Elements:
Analysis of Plane Elasticity Problems: Triangular element, four noded quadrilateral Element (QUAD4), shape functions for higher order elements (LST and QUAD 8), Lagrange element, stain –displacement matrix, stiffness matrix and Jacobian of CST and QUAD4 elements.

Axi-symmetric Solid elements:
Analysis of Bodies of revolution under axi-symmetric loading, Axi-symmetric Triangular and Quadrilateral Ring Elements, Strain- Displacement matrix, stiffness matrix

Module-4

Three dimensional elements:
Applications to Solid mechanics Problems: Basic Equations and Potential Energy Functional, Four Noded Tetrahedral Element, Eight - Noded Hexahedral Element, LaGrange family, Shape Functions for Higher Order Elements.

Beam elements
Analysis of beam and frames: 1-D Beam element Problems

Module-5

Dynamic Considerations: Formulation of point mass and distributed mass, Consistent element mass matrix of one dimensional bar element, truss element, beam element, Lumped mass matrix, Evaluation of Eigen values and Eigen vectors. Applications to bars and beam element

Heat Transfer:
Steady state heat transfer, 1D heat conduction governing equations. Functional approach for heat conduction. Galerkin's approach for heat conduction. 1D heat transfer in thin fins

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Finite Elements in Engineering ,	T. R. Chandrupatla, A. D. Belegundu	3rd Ed PHI. 3rd Edition	
2	Finite Elements in Engineering	S. S. Rao	4th Edition, Elsevier, 6th Edition	
3	Finite Element Methods for Engineers	U.S. Dixit	Cengage Learning, 1st Edition	2009

4	Concepts and applications of Finite Element Analysis	R. D. Cook, D. S Maltus, M. E. Plesha, R. J. Witt	Wiley 4th Ed 4th Edition	2001
5	Finite Element Methods	Erik G. Thompson	Thomson Learning 3rd edition, 5th Edition	2012
6	Finite Element Method	J. N. Reddy	McGraw -Hill, 3rd Edition International Edition.	2006

(Group-3):	**Course Code :** 20MTP332
Course Title: NON-CONVENTIONAL ENERGY SOURCES	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction: Energy source, India's production and reserves of commercial energy sources, need for nonconventional energy sources, energy alternatives, solar, thermal, photovoltaic. Water power, wind biomass, ocean temperature difference, tidal and waves, geothermal, nuclear (Brief descriptions). **Solar Radiation:** Extra-Terrestrial radiation, spectral distribution of extra-terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data. **Measurement of Solar Radiation:** Pyrometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working.

Module-2

Solar Radiation Geometry: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle expression for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time. Apparent motion of sum, day length, numerical examples. **Solar Thermal systems:** Flat plate collector; Evacuated Tubular Collector; Solar air collector; Solar concentrator; Solar distillation; Solar cooker; Solar refrigeration and air conditioning; Thermal energy storage systems. Solar pond, principle of working. **Solar Photovoltaic systems:** Introduction; Solar cell Fundamentals; Characteristics and classification; Solar cell: Module, panel and Array construction

Module-3

Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis wind mills, elementary design principles; coefficient of performance of a wind mill rotor, aerodynamic considerations of wind mill design, numerical examples.

Module-4

Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations. **Ocean Thermal Energy Conversion:** Principle of working, Rankine cycle, OTEC power stations in the world, problems associated with OTEC.

Module-5

Geothermal Energy Conversion: Principle of working, types of geothermal station with schematic diagram, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy. **Energy from Bio Mass**: Photosynthesis, photosynthetic oxygen production, energy plantation, bio gas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of biogas, problems involved with bio-gas production, application of bio-gas, application of bio-gas in engines, advantages

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

1. Non-Conventional Energy Sources, G.D Rai, Khanna Publishers, 2003.
2. Non-Convention Energy Resources, B H Khan, McGraw Hill Education (India) Pvt. Ltd. 3rd Edition
4. Solar energy, Subhas P Sukhatme, Tata McGraw Hill, 2nd Edition, 1996.
5. Renewable Energy Sources and Conversion Technology, N K Bansal, Manfred Kleeman & Mechael Meliss, Tata McGraw Hill. 2004.
6. Non-Conventional Energy, Ashok V Desai, Wiley Eastern Ltd, New Delhi, 2003.
7. Renewable Energy Technologies, Ramesh R & Kumar K U, Narosa Publishing House, New Delhi.

(Group-3):	**Course Code : 20MTP252**
Course Title: MODELING AND SIMULATION OF THERMAL SYSTEMS	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Principle Of Computer Modeling And Simulation: Monte Carlo simulation, Nature of computer modeling and simulation, limitations of simulation, areas of application. **System and Environment:** components of a system-discrete and continuous systems. Models of a system-a variety of modeling approaches.

Module-2

Random Number Generation: technique for generating random numbers —mid squad e method- The mid product method- constant multiplier technique-additive congruential method- linear congruential method - tests for random numbers the kolmogorov-simrnov test-the Chi-square test. **Random Variable Generation:** inversion transforms technique- exponential distribution- uniform distribution-Weibul distribution empirical continuous distribution- generating approximate normal variants-Erlang distribution.

Module-3

Empirical Discrete Distribution: Discrete uniform distribution - Poisson distribution geometric distribution-acceptance-rejection technique for Poission distribution-gamma distribution. **Design And Evaluation Of Simulation Experiments**: variance reduction techniques-antithetic variables- variables-verification and validation of simulation models.

Module-4

Discrete Event Simulation: concepts in discrete-event simulation, manual simulation using event scheduling, single channel queue, two server queue simulation of inventory problem.

Module-5

Introduction to GPSS: Programming for discrete event systems in GPSS, case studies.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

1. Discrete event system simulation - Jerry Banks & John S Carson II, prentice hall Inc, 1984.
2. Systems simulation - Gordon g, prentice Hall of India Ltd, 1991.
3. System simulation with digital Computer – Narsingh Deo, Prentice Hall of India, 1979.
4. Thermal Power Plant Simulation & Control - D. Flynn (Ed), IET, 2003.

(Group-3):	**Course Code :** 20MMD251
Course Title: AUTOMOBILE SYSTEM DESIGN	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Body Shapes: Aerodynamic Shapes, drag forces for small family cars. Fuel Injection: Spray formation, direct injection for single cylinder engines (both SI & CI), energy audit	
Module-2	
Design of I.C. Engine I: Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines.	
Module-3	
Design of I.C. Engine II: Design of crankshaft, camshaft, connecting rod, piston &piston rings for small family cars (max up to 3 cylinders)	
Module-4	
Transmission System: Design of transmission systems – gearbox (max of 4- speeds), differential suspension System: Vibration fundamentals, vibration analysis (single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension.	
Module-5	
Cooling System: Heat exchangers, application to design of cooling system (water cooled). Emission Control: Common emission control systems, measurement of emissions, exhaust gas emission testing	
Question paper pattern: The question paper will be set for 100 marks • The question paper will have ten full questions carrying equal marks. • Each full question is for 20 marks. • There will be two full questions (with a maximum of four sub questions) from each module. • Each full question will have sub question covering all the topics under a module. • The students will have to answer five full questions, selecting one full question from each module.	
Textbook/ Textbooks	
1. Design of Automotive Engines, A.Kolchin &V. Demidov, MIR Publishers, Moscow. 2. The motor vehicle, Newtons teeds & Garratte-Iliffee & sons Ltd., London. 3. I.C. Engines -Edward F. Obert, International text book company.	
Reference Books	
1. Introduction to combustion-Turns. 2. Automobile Mechanic-, N.K.Giri, Khanna Publications, 1994 3. I.C. Engines -Maleev, McGraw Hill book company, 1976 4. Diesel engine design- Heldt P.M., Chilton Company New York. 5. Problems on design of machine elements- V.M. Faires &Wingreen, McMillan Company.,1965 6. Design of I.C. Engines -John Heywood, TMH.	

Group-3):	**Course Cod : 20 MST 244**
Course Title: ADVANCED MATERIALS AND PROCESSING	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Classification and Characteristics: Metals, Nonferrous Metals and Ferrous Metals, classification of Ferrous Metals and Non-Ferrous Metals, Types of Ceramics, Polymers and composites and classification of composites. General Properties and Structure: Atoms, molecules bonds in solids, Crystalline – Defects in Metallic structure, Dislocations and plastic deformation - Strengthening mechanism – grain size, dislocation - Cold work, precipitation hardening, dispersion hardening - phase reactions, fatigue and Creep behaviour.

Module-2

Ferrous Alloys: iron carbon equilibrium diagrams - Steels and cast irons - properties, structure, composition and applications transformation hardening in steels - TIT diagrams - Heat treatment processes - Effect of alloying elements - High alloy steels, Stainless steel types, tool Steels, Manganese steels, heat resistant steels, HSLA, Managing steels. Non-Ferrous Alloys: Alloys of copper, Aluminium, nickel, magnesium, titanium, lead, tin, Zinc - composition, heat treatment, structure, properties and application.

Module-3

Polymers and Polymerizations: Structure and properties of thermoplastics and thermosets-Engineering Applications - property modifications - Mechanical and thermal behaviour – processing methods Ceramics: Nature and structure of Ceramics - Refractory Abrasives glasses - glass ceramics - Advanced ceramics processing methods.

Module-4

Composites: Definition - classification and characteristics of composite materials - Volume fraction - laminated composites particulate composites, fibrous composites – Types of reinforcements, their shape and size - production and properties of fiber reinforced plastics, Metal Matrix composites and ceramic matrix composites - Applications.

Module-5

Processing of Polymers: composites, ceramics - thermal spraying - Ion beam machining diamond coating techniques-tribological applications.

Course outcomes:

At the end of the course the student will be able to:

1. Understand and apply the various processing and manufacturing techniques. (PO-5)
2. Knowledge of basics of process and important parameters of equipment design. (PO-3)
3. Understand and apply the techniques and their characteristics/limitations of synthesis of polymers. (PO-1,5)
4. Understand the structure-processing-property relationship of metals and polymers. (PO-3)
5. Understand the basic issues involved in polymer blends, metal matrix composites and ceramic matrix composites. (PO-2)
6. Understand the significance of alloying element and phase diagrams. (PO-3,4)

Question paper pattern:

The question paper will be set for 100 marks.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

Advanced Materials and Processes - James W. Evans Lutgard C. De Jonghe. Springer Publications – 2016.
1. Engineering Metallurgy - Raymond and Higgens - ELBS/EA
2. Introduction to Material Science and Engineering James. F. Shackleford - Mc Millan, NY - 7th edition.

Reference Books

1. Powder Metallurgy-Metals Hand Book -ASM, USA - Vol.7, 1974.
2. Composite Materials - Science and Engineering - Chawla K.K., - Springer - Verlag, New York - 2nd edition, 1998.
3. Cast Metal Matrix Composites ASM Metals Hand Book - P.K. Rohagti - VI5.
4. Elements of Material Science and Engineering - Van Vlack L.H. - Addison Wesley, NY- 1989.
5. Material science and metallurgy - by Callister, John Willey & Sons.

Group-3):	**Course Code : 20CAE241**
Course Title: CIM & ROBOTICS for AUTOMATION	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction to Computer integrated Manufacturing Systems: Manufacturing Systems, Types of Manufacturing Systems, , Machine Tools and related equipment's, Material Handling Systems, Computer monitoring and control, Manufacturing support systems, The Product Cycle and CAD/ CAM, Functions of computers in CIMS: CIMS Data Files, System Reports, Benefits of Computer integrated Manufacturing Systems, NC/ CNC Machine Tools: General architecture of CNC Machine, Components of the CNC Systems: Machine Control Unit , CNC Driving system components: Hydraulic, Servo Motors, Stepper Motors, Feedback Devices: Encoder, Resolver, Inductors, Tachometers, Counting devices, Digital to analog converters.

Module-2

part programming: Introduction, NC/ CNC programming methods: Manual part programming for turning and milling centers, G codes, M codes, canned cycles, Programming with CAD/CAM integration, CAM packages for CNC part program generation, Practical Exercises on CNC part programming. Computer Controls in NC: CNC Technology: Functions of CNC Control in Machine Tools, Advantages of CNC, Direct Numerical Control (DNC Systems): Configuration of DNC system, Functions of DNC, Communication between DNC computer & MCU, Advantages of DNC, Adaptive control machining systems. Adaptive control optimization system, adaptive control constraint system, applications to machining processes, Benefits of Adaptive control machining.

Module-3

Introduction to Robotics: Automation and Robotics, Historical Development, Definitions, Basic Structure of Robots, Robot Anatomy, Complete Classification of Robots, Fundamentals about Robot Technology, Factors related to use Robot Performance, Basic Robot Configurations and their Relative Merits and Demerits, Types of Drive Systems and their Relative Merits, the Wrist & Gripper Subassemblies. Concepts and Model about Basic Control System, Transformation and Block Diagram of Spring Mass System, Control Loops of Robotic Systems, PTP and CP Trajectory Planning, Different Types of Controllers, Control Approaches of Robots.

Module-4

Kinematics of Robot Manipulator: Introduction, General Description of Robot Manipulator, Mathematical Preliminaries on Vectors & Matrices, Homogenous Representation of Objects, Robotic Manipulator Joint Co-Ordinate System, Euler Angle & Euler Transformations, Roll-Pitch-Yaw(RPY) Transformation, Relative Transformation, Direct & Inverse Kinematics' Solution, D H Representation Displacement Matrices for Standard Configurations, Geometrical Approach to Inverse Kinematics. Homogeneous Robotic Differential Transformation: Introduction, Jacobian Transformation in Robotic Manipulation.

Module-5

Robotic Workspace, Motion Trajectory & Industrial Applications: Introduction, General Structures of Robotic Workspaces, Manipulations with n Revolute Joints, Robotic Workspace Performance Index, Extreme Reaches of Robotic Hands, Robotic Task Description. Robotic Motion Trajectory Design: Introduction, Trajectory Interpolators, Basic Structure of Trajectory Interpolators, Cubic Joint Trajectories. General Design Consideration on Trajectories: 4-3-4 & 3-5-3 Trajectories, Admissible Motion Trajectories.

Industrial Applications: Automation in Manufacturing, Robot Application in Industry, Task Programming, Goals of AI Research, AI Techniques, Robot Intelligence and Task Planning, Modern Robots, Future Application and Challenges and Case Studies.

Course outcomes:

At the end of the course the student will be able :

1. To impart the basic concepts in manufacturing systems and fundamentals of NC & CNC system
2. Enhance knowledge in design consideration and increasing productivity with NC machine tools, machining centers and tooling for CNC machines
3. To Understand the robotic system, available tools and technique for kinematics and its applications to industry

Question paper pattern:

The question paper will be set for 100 marks

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbooks/

1. GROOVER M P, Automation, Production Systems and Computer Integrated Manufacturing - , Prentice Hall India (P) Ltd, 1989.
2. Mikell P. Groover and Emory W. Zimmer, Jr., CAD/CAM Computer Aided Design and Manufacturing, Prentice Hall India (P) Ltd, 1992.
3. M.Koren ―Computer Controls of Manufacturing Systems, McGraw Hill, 1983
4. "A Robot Engineering Textbook "– Mohsen Shahinpo or – Harper & Row publishers,
5. "Robotics, control vision and intelligence," Fu, Le e and Gonzalez. McGraw Hill International, 1987.
6. "Introduction to Robotics: Mechanics and Control", John J. Craig, Pearson, 3e, 2009.

Reference Books

1. Martin J. ―Numerical control of machine tools".
2. P.N. Rao – CAD/CAM Principles and Applications McGraw hill 2002
3. Y. Koren & J.Benuri -"Numerical control of machine tools-Khanna, 1992
4. Wilson F.M ―Numerical control in manufacturing- McGraw Hill New York
5. Suk-Hwan Suh, Seong-Kyoon Kang, Dea-Hyuk Chung and Ian Stroud, Theory and Design of CNC Systems, Springer, 2008.
6. "Robotics for Engineers", Yoram Koren, McGraw Hill International, 1985.
7. "Industrial Robotics", Groover, Weiss, Nagel, McGraw Hill International, 1986.
8. "Robot Technology Fundaments"- Keramas, Thomson Vikas Publication House, 1999.

(Group-3):	**Course Code : 20MTP14**
Course Title: COMBUSTION THERMODYNAMICS	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction: Thermodynamics-equation of state, properties of gas mixtures, First law analysis of reacting systems, enthalpy of formation and heat of reaction, stoichiometric and equivalence ratio, adiabatic flame temperature. **Fuels and combustion**: Coal, fuel oil, natural and petroleum gas, emulsion firing, coal – oil and coal – water mixtures, synthetic fuels, bio-mass, combustion reactions, heat of combustion and enthalpy of combustion, theoretical flame temperature, free energy of formation, equilibrium constant, effect of dissociation. Combustion Mechanisms: Kinetics of combustion, mechanisms of solid fuel combustion, kinetic and diffusion control, pulverized coal firing system, fuel-bed combustion, fluidized bed combustion, coal gasifiers, combustion of fuel oil, combustion of gas, combined gas fuel oil burners, Requirements for efficient combustion , Recent trends in furnace /combustion chamber.

Module-2

Second law of thermodynamics and concept of chemical equilibrium: Gibbs free energy and the equilibrium constant of a chemical reaction (Vant-Hofts equation). Calculation of equilibrium Composition of a chemical reaction.

Module-3

Chemistry of Combustion: Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics. **Physics of Combustion:** Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow.

Module-4

Premixed Flame: One dimensional combustion wave, Laminar premixed flame, Burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Flame extinction, Ignition, Flame stabilizations, Turbulent Premixed flame

Module-5

Diffusion Flame: Gaseous Jet diffusion flame, Liquid fuel combustion, Atomization, Spray Combustion, Solid fuel combustion, Combustion and Environment: Atmosphere, Chemical Emission from combustion, Quantification of emission, Emission control methods.

Question paper pattern:

The question paper will be set for 100 marks

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

(1) Mishra, D.P., Introduction to Combustion, Prentice Hall,2009

(2)Sharma, S. P., Fuels and Combustion, Tata McGraw Hill, New Delhi, 2001.

(3) Heywood Internal Combustion Engine Fundamentals, McGraw Hill Co.1988

Reference Books

(1) Thermodynamics – An Engineering Approach, Yunus Cengel and Michael Boles,7th Ed., Tata McGraw Hill

(2) Modern Engineering Thermodynamics, Robert Balmer, Elsevier.

(3)Advanced Thermodynamics for Engineers, Kenneth Wark, McGraw Hill

(4)Principles of Combustion, Kuo K. K., John Wiley and Sons.

(5)An Introduction to Combustion concepts and application by Stephen R. Turns, McGraw Hill Heigher Education, 2000.

(Group-3): **Course Code : 20MTE252**

Course Title: RAPID PROTOTYPING

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction: Definition of Prototype, Types of prototype, Need for the compression in product development, History of RP systems, Survey of applications, Growth of RP industry and classification of RP systems.
Stereo lithography Systems: Principle, Process parameter, process details, Data preparation, data files and machine details, Application

Module-2

Selective Laser Sintering: Type of machine, Principle of operation, process parameters, Data preparation for SLS, Applications, Fusion Deposition Modelling: Principle, Process parameter, Path generation, Applications

Module-3

Solid Ground Curing: Principle of operation, Machine details, Applications.
Laminated Object Manufacturing: Principle of operation, LOM materials, process details, application.
Concepts Modelers: Principle, Thermal jet printer, Sander's model market, 3-D printer, GenisysXs printer HP system 5, object Quadra systems.
Laser Engineering Net Shaping (LENS).

Module-4

Rapid Tooling : Indirect Rapid tooling -Silicon rubber tooling -Aluminum filled epoxy tooling, Spray metal tooling, Cast kirksite, 3D keltooletc, Direct Rapid Tooling - Direct AI M, Quick cast process, Copper polyamide, Rapid Tool, DMILS, Pro Metal, Sand casting tooling, Laminate tooling soft Tooling vs. hard tooling.

Module-5

Software For Rp: Stl files, Overview of Solid view, magics, imics, magic communicator, etc. Internet based software, Collaboration tools.
RAPID Manufacturing Process Optimization: factors influencing accuracy, data preparation errors, Part building errors, Error in finishing, influence of build orientation.
Allied Processes: vacuum casting, surface digitizing, surface generation from point cloud, surface modification - data transfer to solid models.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Stereo 1ithography and other RP & M Technologies	Paul F. Jacobs	SME NY	1996
2	Rapid Manufacturing	Flham D.T &Dinjoy S.S,	Verlog London	2001
3	Wohler's Report 2000	Terry Wohler's	Wohler's Association	2000

(Group-4):	**Course Code** : **20MAU14**
Course Title: AUTOMOTIVE CHASSIS & POWER TRANSMISSION	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Overview of Vehicle Chassis System:
General construction of chassis, Types of chassis layouts with respect to location of Power plant and drive arrangements and their comparison. Stability of vehicle on slope, weight distribution, numerical on above topics.
Frames:
Types of frames, loads acting of frame, cross sections and materials for frames, loading points, sub frames, calculation of cross section of frame members, Testing of frames numerical on above topics.

Module-2

Front axle and Steering Systems:
Front axle: Types of front axles and stub axles, Axle parts and materials, loads and stresses, Front wheel geometry- calculation of cross sections of front axles. **Steering Systems:** Condition for correct steering, types of steering gears, power steering, Types of linkages, Ackermann and Davis steering mechanisms, Reversible and Irreversible steering.
Suspension System:
Types of suspension system Constructional details of leaf spring, helper springs, coil springs, torsion bar, rubber springs, plastic springs, air bellows or pneumatic suspension, hydraulic suspension, constructional details of telescopic shock absorbers, independent suspension, front wheel independent suspension, rear wheel independent suspension, types, stabilizer, trouble shooting.

Module-3

Brakes:
Necessity and requirements of brakes, stopping distance and time, brake efficiency, weight transfer, brake shoe theory, determination of braking torque, Classification of brakes, constructional details- Drum brakes, Disc brakes Hydraulic brake system, Pneumatic brakes, Power assisted Braking system, Servo Brakes, Anti-lock Braking system, Retarders, Hill Holders, requirements of brake fluids, requirements and construction of brake shoes, trouble shooting.

Module-4

Overview of Vehicle Power Trains System:
Outlines of Power Trains, Power train functions, Power train layout and components, Main and Auxiliary functions, Requirements profile, Interrelations: Direction of rotation, Transmission Ratio and Torque, Road Profiles, Load Profiles, Typical Vehicle uses and Driver types, Performance features of Vehicle Transmissions. Design trends in Transmission, Kinematical relations of power trains, Numerical problems.
Matching Engine and Transmission:
Road loads and axle loads, Deriving condition diagram, Ideal transmission and engine-transmissions matching, Total ratio and overall gear ratio Selecting the largest power- train ratio, Selecting the smallest power- train ratio, Selecting the intermediate gears- saw tooth profile, Geometrical gear steps, Progressive gear steps, Numerical problems.

Module-5

ManualTransmissions:
Manual Transmission Layouts and Components, Basic gear box construction, gear-sets with fixed axles, countershaft transmission and epicyclic gears, schemes for reverse gear. Transmission Power Flows, Numerical problems
Automatic Transmissions: Level of automation, Gear shift mode, stepped and Continuously Variable Transmissions, synchronizer gear boxes, epi-cycloidal gear boxes, Design and analysis of planetary gear trains, Gear ratios and clutch engagement schedule, Clutch torques in steady state condition, Torque analysis in shifting process, Numerical problems.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books				
	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Automotive Chassis	PP.M. Heldt	Chilton & Co. Edition	1990
2	Automotive Mechanics	N.K. Giri	Khanna Publications, 8th	2008
3	Automotive mechanics	Joseph I Heintner	Affiliate d East West Press, New Delhi	1967
4	Handbook of Automotive Power train and Chassis Design	J. Fenton	Professional Engineering Publishing, London 1st Edition	1998
5	Kirpal Singh	Automobile Engineering Vol. I,	Standard publications, New Delhi.13th Edition	2012

(Group-4): **Course Code : 20MAU22**

Course Title: AUTOTRONICS

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Electrical and electronic principles: Safe working practices , Basic electrical principles, Electronic components and circuits, Digital electronics, Microprocessor systems , Measurement , Sensors and actuators , Diagnostics - electronics, sensors and actuators

Tools and test equipment: Basic equipment : Basic Hand Tools, accuracy of test equipment, : Multi-meters , Specialist equipment: Oscilloscope pressure testing, engine analysers scanner, Dedicated equipment-serial port communications Laser 2000 electronic systems tester, On-board diagnostics , Diagnostic procedures

Module-2

Electrical systems and circuits: The systems approach: vehicle system, open and closed loop systems; Electrical wiring, terminals and switching: cables, colour codes, printed circuits, fuses and circuit breakers, Terminators , switches , Multiplexed wiring systems , Circuit diagrams and symbols , Electromagnetic compatibility (EMC)

Batteries: Requirement, Construction, Principle of operation, Working of Lead acid, alkaline, Zebra, Sodium Sulphur, Swing batteries, Ratings, Charging, Maintenance & testing of Lead acid battery. Introduction to fuel cells, proton exchange membrane fuel cell, alkaline fuel cell.

Module-3

Charging systems: Requirements of the charging system, Charging system principles, Alternators and charging circuits, Diagnosing charging system faults

Starting systems: Requirements of the starting system, Starter motors and circuits , Types of starter motors: Inertia starters, pre engaged starters, permanent magnet starters, heavy vehicle starters, integrated starters, ,Diagnosing starting system faults

Module-4

Ignition systems: Electronic ignition: Introduction, constant dwell systems, constant energy systems, hall effect pulse generator, inductive pulse generator; programmed ignition, distributor less ignition.

Lighting: Lighting fundamentals, Lighting circuits, Gas discharge and LED lighting, Diagnosing lighting system faults

Module-5

Chassis electrical systems: Anti-lock brakes ,Active suspension, Traction control , Automatic transmission ,Other chassis electrical systems , Diagnosing chassis electrical system faults

Auxiliaries: Windscreen washers and wipers: functional requirements, wiper blades, wiper linkages, wiper motor ; washer and wiper circuits, electronic control of wipers, microprocessor controlled wipers, Signalling circuits; Other auxiliary systems: electric horns, engine cooling fan motors

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Automobile Electrical & Electronics Elsevier Butterworth	Tom Denton	Heinemann 3rd Edition	2004
2	Understanding Automotive Newnes	William B. Ribbens	Elsevier Science Electronics 6th Edition	2003
3	Michel Parent, Fumio Intelligent Vehicle Technologies	Ljubo Vlacic	Butterworth-Heinemann 1st Edition	2001

4	Automotive Electronic Hand book	Ronald K. Jurgen	McGraw Hill Professional 2nd Edition	1999
5	Automotive Mechanics	William Crouse and Anglin	Glencoe, 10th Edition	1993

(Group-4): **Course Code : 20MAU241**

Course Title: DRIVERLESS VEHICLES

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction to autonomous driving: autonomous driving technologies overview, autonomous driving algorithms: Sensing, Perception, Object Recognition and Tracking:
Autonomous driving client system: Robot Operating System, Hardware platform:
Autonomous driving cloud platform: Simulation, HD Map Production, Deep learning Model Training

Module-2

Autonomous vehicle localization:
Localization with GNSS: GNSS overview, GNSS error analysis, satellite based augmentation systems, real time kinematic and differential GPS, precise point positioning, GNSS INS integration Localization with LiDAR and HD maps
Visual Odometry: Stereo Visual Odometry, Monocular Visual Odometry, Visual Inertial Odometry, Dead Reckoning and Wheel Odometry; Sensor fusion

Module-3

Perceptions In Autonomous driving: Introduction, Datasets, Detection, Segmentation, Sterio, Optical flow and Scene flow
Deep learning in Autonomous Driving Perception: Convolutional Neural Networks, Detection, Semantic segmentation, Stereo and optical flow

Module-4

Prediction and Routing: Planning and control overview, Traffic prediction: Behaviour prediction as classification, Vehicle trajectory generation,
Lane level routing: Constructing a weighted directed graph for routing, typical routing algorithms, routing graph

Module-5

Decision planning and control: Behavioural decisions, Motion planning, Feedback control Reinforcement Learning Based Planning and Control,
Client systems for Autonomous Driving: Operating systems and computing platform
Cloud platform for Autonomous driving: Introduction, infrastructure , simulation

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Creating Autonomous Vehicle Systems	Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc	Morgan & Claypool Publishers 1st Edition	2018
2	Jurgen Autonomous Vehicles for Safer Driving	Ronald K.	SAE International Edition	2013
3	Intelligent Cars and the Road ahead	Hod Lipson, Melba Kurman	MIT Press. 1st Edition,	2016
4	Barbara Lenz Autonomous Driving	Markus Maurer, J. Christian Gerdes	Technical, Legal and Social Aspects 1st Edition	2016

5	Autonomous Vehicles and the Law: Technology, Algorithms and Ethics	Hannah Yee Fen Lim	Edward Elgar Publishing. 1st Edition	2018

(Group-4): **Course Code : 20MAU31**

Course Title: HYBRID AND ELECTRIC VEHICLES

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Hybrid Vehicles:
Introduction to HVs, Performance characteristics of road vehicles; calculation of road load, predicting fuel economy, grid -connected hybrids.

Hybrid architecture:
Series configuration- locomotive drives, series parallel switching, load tracking architecture. Pre transmission parallel and combined configurations-Mild hybrid, power assist, dual mode, power split, power split with shift, Continuously Variable transmission (CVT), wheel motors

Module-2

Propulsion methods:
DC motors-series wound, shunt wound, compound wound and separately excited motors AC motors-Induction, synchronous, brushless DC motor, switched reluctance motors.

Module-3

Hybrid power plant specifications:
Grade and cruise targets, launching and boosting, braking and energy recuperation, drive cycle implications, engine fraction-engine downsizing and range and performance, usage requirements.

Sizing the drive system:
Matching electric drive and ICE, sizing the propulsion motor; sizing power electronics

Module-4

Energy storage technology:
Battery basics; lead-acid battery; different types of batteries; battery parameters, Battery Recycling.

Fuel cells:
Fuel cell characteristics, fuel cell types – alkaline fuel cell, proton exchange Membrane; direct methanol fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, hydrogen storage systems, reformers, fuel cell EV, super and ultra capacitors.

Module-5

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

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Development & Future of Battery The Institution of Electrical Engineers	Mike Westbrook, M H Westbrook	UK and SAE, USA1st Edition, reprint	2005
2	Iqbal Husain Electric and Hybrid Vehicle	Robin Hardy	CRC Press, 1st Edition	2003
3	Handbook of Electric Motors	Hamid A Toliyat, Gerald B Kliman	Marcel Decker Inc. 2nd Edition	2004

4	International Energy Agency		France Energy Technology Analysis Prospects for Hydrogen and Fuel Cells OECD, 1st Edition	2005

(Group-4):	**Course Code :** 20MTP15
Course Title: ADVANCED POWER PLANT CYCLES	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Analysis of Steam cycles: Rankine cycle, Carnot cycle, mean temperature of heat addition, effect of variation of steam condition on thermal efficiency of steam power plant, reheating of steam, regeneration, regenerative feed water heating, feed water heaters, carnotization of Rankine cycle, optimum degree of regeneration, Super critical pressure cycle, steam power plant appraisal, Deaerator, typical layout of steam power plant, efficiencies in a steam power plant, Cogeneration of Power and Process Heat, Numerical Problems. Combined cycle power generation: Flaws of steam as working fluid in Power Cycle, Characteristics of ideal working fluid in vapor power cycle, Binary vapor cycles, coupled cycles, combined cycle plants, gas turbine- steam turbine power plant, MHD-steam power plant, Thermionic- Steam power plant.

Module-2

Steam Generators: Basic type of steam generators, fire tube boilers, water tube boilers. Economizers, super heaters, re heaters, steam generator control, air preheater, fluidized bed boilers, electrostatic precipitator, fabric filters and bag houses, ash handling system, feed water treatment, de-aeration, evaporation, internal treatment, boiler blow down, steam purity, Numerical problems. Condenser, feed water and circulating water systems: Need of condenser, direct contact condensers, feed water heaters, circulating water system, cooling towers, calculations, Numerical Problems.

Module-3

Nuclear Power Plants: Chemical and nuclear reactions, nuclear stability and binding energy, radioactive decay and half-life, nuclear fission, chain reaction, neutron energies. Neutron flux and reaction rates, moderating power and moderating ratio, variation of neutron cross sections with neutron energy, neutron life cycle. Reflectors, Types of Reactor, PWR, BWR, gas cooled reactors. Liquid metal fast breeder reactor, heavy water and Fusion Power reactors. Safety in nuclear power plants.

Module-4

Hydro Electric Power Plant: Introduction, advantages and disadvantages of water power, optimization of hydro – thermal mix, hydrological cycles, storage and pondage Power plant Economics: Definitions, Principles, Location of power plant, cost analysis selection of type of generation, selection of power plant equipment's

Module-5

Pollution and its effects: Definition, Cause, effects and control measures of - Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution and Nuclear hazards, Solid waste Management, Disaster management Role of an individual in prevention of pollution, Pollution case studies.

Social Issues and the Environment: Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies. Wasteland reclamation, Consumerism and waste products, Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation.

Question paper pattern:

The question paper will be set for 100 marks

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

1. Power Plant Engineering - P.K. Nag, Tata McGraw-Hill Publications. 2nd edition

2. Power Plant Engineering - M.M. EI-Wakil, McGraw- Hill Publications. 1st edition

3. Power plant engineering - R.K.Rajput, Laxmi Publications 3rd edition

(Group-4): **Course Code : 20MTP331**

Course Title: EXPERIMENTAL METHODS IN THERMAL POWER ENGINEERING

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Basics of Measurements: Introduction, General measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction. **Pressure measurement:** Different pressure measurement instruments and their comparison, Transient response of pressure transducers, dead-weight tester, low-pressure measurement.

Module-2

Thermometry: Overview of thermometry, temperature measurement by mechanical, electrical and radiation effects. Pyrometer, Thermocouple compensation, effect of heat transfer. **Thermal and transport property measurement:** Measurement of thermal conductivity, diffusivity, viscosity, humidity, gas composition, pH, heat flux, calorimetry, etc.

Module-3

Flow Measurement: Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, flow measurement by drag effects, pressure probes, other methods. **Nuclear, thermal radiation measurement:** Measurement of reflectivity, transmissivity, emissivity, nuclear radiation, neutron detection, etc. Other measurements: Basics in measurement of torque, strain.

Module-4

Analysis of experimental data: Causes and types of errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis, Statistical analysis of Experimental data. **Sensing Devices:** Transducers-LVDT, Capacitive, piezoelectric, photoelectric, photovoltaic, Ionization, Photoconductive, Hall-effect transducers, etc.

Module-5

Air-Pollution: Air-Pollution standards, general air-sampling techniques, opacity measurement, sulphur dioxide measurement, particulate sampling technique, combustion products measurement. **Advanced topics:** Issues in measuring thermo physical properties of micro and Nano fluids. **Design of Experiments:** Basic ideas of designing experiments, Experimental design protocols with some examples and DAS.

Course outcomes:

At the end of the course the student will be able to:

- CO1: Understand the concepts of errors in measurements, statistical analysis of data, regression analysis, correlation and estimation of uncertainty.
- CO2: Describe the working principles in the measurement of field and derived quantities.
- CO3: Examine sensing requirements for measurement of thermo-physical properties, radiation properties of surfaces, and vibration.
- CO4: Understand conceptual development of zero, first and second order systems.
- CO5: Interpret International Standards of measurements (ITS-90) and identify internationally accepted measuring standards for measurands.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

1. Modern Electronic Instrumentation and Measurement Techniques; Albert D Helfrick and William D Cooper, 2004, PHI.
2. b. Process Control: Principles and Applications; Surekha Bhanot, Oxford University press, Fourth Impression, 2010.
3. Instrumentation, Measurement and Analysis; BC Nakra, and KK Chaudhry; 2 ed, 2004, Tata McGraw-Hill

4.	Transducers and Instrumentation; DVS Murthy, 2003, PHI
5.	Instrumentation Devices and Systems; CS Rangan, GR Sarma, and VSV Mani; 2 ed, Tata McGraw-Hill
6.	Measurement Systems Application and Design; Doeblin and Ernest; 5 Ed, 2004, Tata McGraw-Hill.
7.	Measurement Systems – Applications & design; Doeblin E.O. 4th ed. Mc. Graw Hill
8.	Principles of Industrial Instrumentation, Patranabis D. TMH – 1997
9.	Mechanical & Industrial Measurements, Jain R.K, Khanna Publishers – 1986
10.	Process Instruments and control Hand book, Considine D.M, 4th ed, McGraw Hill
11.	Instrument Technology – Vol.1m, Jones E.B., Butterworths – 1981
12.	Control Systems Engineering, Nagrath & M.Gopal, Wiley Eastern
13.	Automatic Control Systems, B.C.Kuo, John Wiley, 2009
14.	Modern Control Engineering, Katsuhiko Ogata, Prentice Hall

(Group-4):	**Course Code : 20MMD332**
Course Title: DESIGN OPTIMIZATION	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Engineering Design Practice: Evolution of Design Technology, Introduction to Design and the Design Process, Design versus Analysis, Role of Computers in Design Cycle, Impact of CAE on Design, Numerical Modelling with FEA and Correlation with Physical Tests.

Applications of Optimization in Engineering Design: Automotive, Aerospace and General Industry Applications, Optimization of Metallic and Composite Structures, Minimization and Maximization Problems, MDO and MOO.

Module-2

Optimum Design Problem Formulation: Types of Optimization Problems, The Mathematics of Optimization, Design Variables and Design Constraints, Feasible and infeasible Designs, Equality and Inequality Constraints, Discrete and Continuous Optimization, Linear and Non-Linear Optimization.

Optimization Theory–Fundamental Concepts, Global and Local Minimum, Gradient Vector and Hessian Matrix, Concept of Necessary and Sufficient Conditions, Constrained and Unconstrained Problems, Lagrange Multipliers and Kuhn Tucker Conditions.

Module-3

Sensitivity Analysis: Linear and Non-Linear Approximations. Gradient Based Optimization Methods - Dual and Direct.

Optimization Disciplines: Conceptual Design Optimization and Design Fine Tuning, Combined Optimization, Optimization of Multiple Static and Dynamic Loads, Transient Simulations, Equivalent Static Load Methods. Internal and External Responses, Design Variables in Each Discipline.

Module-4

Manufacturability in Optimization Problems: Design for Manufacturing, Manufacturing Methods and Rules, Applying Manufacturing Constraints to Optimization Problems.

Design Interpretation: Unbound Problems, Over Constrained Problems, Problems with No of Multiple Solutions, Active and Inactive Constraints, Constraint Violations and Constraint Screening, Design Move Limits, Local and Global Optimum.

Module-5

Dynamic Programming: Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples.

Question paper pattern:

The question paper will be set for 100 marks.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

1. S.S.Rao, Engineering Optimization: Theory and Practice, John Wiley, 2009
2. Jasbir Arora, Introduction to Optimum Design, McGraw Hill, 2011.

Reference Books

1. Optimization and Probability in System Engg-Ram, Van Nostrand.
2. Optimization methods - K. V. Mital and C. Mohan, New age International Publishers

(Group-4): **Course Code : 20MST333**

Course Title: CORROSION SCIENCE AND TECHNOLOGY

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Definition of corrosion, corrosion damage, classification of corrosion, electrochemical aspects, electrochemical reactions, mixed potential theory, Electrode potential, Nernst equation, Oxy-reduction potentials.

Module-2

Corrosion thermodynamics – Pourbaix diagrams; Polarization of the corrosion cell; Activation controlled kinetics and concentration polarization, Evans diagrams, partial corrosion reactions- anodic dissolution of metals; Cathodic reactions – oxygen reduction and hydrogen evolution.

Module-3

Corrosion of materials in natural environments; Atmospheric corrosion, general characteristics, mechanism and prevention; soil corrosion – general characteristics, mechanism and prevention. Localized corrosion damages and materials failure- passivity and transpassivity of metals, breakdown of passivity and pitting corrosion. Stress – corrosion cracking of materials. Inter-granular corrosion failure. Corrosion failure of ceramic materials; mechanisms of corrosion of ceramics, effect of chemical, phase composition and structure on corrosion resistance. Corrosion degradation of concrete.

Module-4

Tafel and linear polarisation, AC impedance, small-amplitude cyclic voltammetry. Paint tests, sea water tests. Interpretation of results, Corrosion prevention; materials selection, alteration of environment, design, Cathodic and anodic protection coating.

Module-5

Environmental effects from the chemical processes industry (like Pulp mill operations, bleach plants, boilers, paper machine, water treatment plants in the pulp and paper industry and others), infrastructure, and transportation industry. Safety aspects.

Course outcomes:

At the end of the course the student will be able to:

- Good knowledge of Corrosion Science.
- Assessment of its impact on its environment.
- Suggest the right technique
- Understand the safety aspects
- Prevent Environment degradation

Question paper pattern:

The question paper will be set for 100 marks.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

Corrosion Science and Engineering (English, Hardcover, Pedeferri Pietro, Publisher: Springer International Publishing AG, 2016.

1. Mars G. Fontana, Corrosion Engineering, McGraw-Hill Book Company, 1986.
2. David Talbot and James Talbot, Corrosion Science and Technology, CRC Press, New York, 1998.
3. Denny A. Jones, Principles and Prevention of Corrosion, Maxwell Matemillar 1992.
4. D. A. Jones: Principles and Prevention of Corrosion, Macmillan Publ. Co. (1996).
5. 2. C. Scully: The Fundamental of Corrosion, 2nd ed., Pergamon Press: E. Stansbury and R. A. Buchanan, Fundamentals of Electrochemical Corrosion, ASM International (2000).
6. 3. M.G. Fontana: Corrosion Engineering, 3rd. Ed., McGraw Hill. (1986)
7. 4. J. M. West: Electrode position and Corrosion Control, J. Wiley W. Revie (ed.):
8. Corrosion Handbook, Electrochemical Society Series, John Wiley and Sons (2000).
9. 5. W. Revie (ed.): Corrosion Handbook, Electrochemical Society Series, John Wiley and Sons, 2000: Metals Handbook, Vol. 13: Corrosion, ASM International

Reference Books

1. Fontana, Mars G, Advances in corrosion science and technology, vol 6. 2012
2. Landolt, Dieter, Corrosion and surface chemistry of metals - 2007
3. Uhlig, Herbert, Corrosion and corrosion control - 4th edn, 1984.

(Group-4):	**Course Code :** 20MAR252
Course Title: DRIVES AND CONTROL SYSTEMS FOR AUTOMATION	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction: Working principle of synchronous, Asynchronous & stepper motors, Difference between Induction and servo motors, Torque v/s speed characteristics, Power v/s. Speed characteristics, Vector duty induction motors, Concepts of linear and frameless motors, Selection of feedback system, Duty cycle.

Module-2

Industrials Drives: DC and AC motors operation and selection, method of control and application of brushless DC motor, PMSM, stepper motor, A.C servomotor, selection criteria for servo motor and servo amplifier, universal motor, electric drive, types of industrial drives, the characteristics of drive, advantages of drives over other prime movers, motor rating, heating effects.

Module-3

Motion Laws For Rotary And Linear Systems: converting rotary to linear system, concepts and principles of ball screws, rack and pinion, belt and pulley, chain drives, gear drives, Selection of converting systems, Dynamic response gearing, and control approaches of Robots, Control loops using Current amplifier

Module-4

Introduction to Programmable Logic Controllers: Definitions of PLC, basic structure of PLC, working principles, data storage methods, inputs / outputs flag processing's, types of variables, definition of firmware, software.

Module-5

Logic, Instructions & Application of PLC: What is logic, Conventional Ladder v/s PLC ladder, series and parallel function of OR, AND, NOT logic, Ex Or logic, Analysis of rung. Timer and Counter Instructions; on delay and Off delay and retentive timer instructions, PLC counter up and down instructions, combining counters and timers, Comparison and data handling instructions, Sequencer instruction, Visualization Systems.

Course outcomes:

At the end of the course the student will be able to:

- Understand the basics of Electric drives
- Explain industrial processes and selection of drives
- Differentiate various control systems
- Develop motor control circuits
- Illustrate computer based industrial control
- Describe Electric traction

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module. ■

Textbook/ Textbooks

(1) Process Control Instrumentation Technology, Johnson Curties, Prentice hall of India, 8th edition Andrew Parr, Industrial drives, Butterworth - Heineamann

(2) Andrew Parr, Industrial drives, Butterworth - Heineamann

(3) G.K. Dubey, Fundamentals of electrical drives

(4) Programmable Logic Controllers by W.Bolton

Reference Books

(1) Introduction to Programmable Logic Controllers by Garry Dunning, 2nd edition, Thomson, ISBN:981-240-625-5

(2) Instrumentation Engineers Hand Book - Process Control, Bela G Liptak, Chilton book company, Pennsylvania

(3) A.E. Fitzerald, C. Kingsley and S.D Umans, Electric Machinery - McGraw Hill Int. Student edition

(4) S.K. Pillai. A First course on electric drives –Wiley Eastern 1990

(5) Programmable Logic Controllers by Hugh Jack.

Ph.D Coursework Courses under Group - 5			
SlNo	**Course Code**	**Course Name**	**Page**
1	20MAU321	Automotive Embedded Systems	70
2	20MAU322	Industry 4.0 And IIOT In Automotive Vehicles	71
3	20MAU323	Advanced Manufacturing Technology	72
4	20MAU334	Automotive Materials	74
5	20MTP241	Energy conservation and management	76
6	20MMD331	Smart Material and Structures	77
7	20MST323	Non- traditional machines	78
8	20MAR251	Networking and IOT	79
9	20MTP324	Phase change phenomena in fluids	80
10	20MTE251	Product Design technology	81

(Group-5): **Course Cod : 20MAU321**

Course Title: AUTOMOTIVE EMBEDDED SYSTEMS

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Electronics in Automotive:
Introduction Body and convenience electronics: vehicle power supply controllers and lighting modules, door control modules, Safety electronics: active safety systems: ABS, ASR, ESP passive safety systems: Restraint systems and their associated sensors in an automobile.
Power train Electronics: Gasoline engine management, Infotainment electronics: Dashboard/instrument cluster, car audio, telematic systems, navigation systems, multimedia systems, cross application technologies, 42V vehicle power supply system

Module-2

Drive by Wire:
Challenges and opportunities of X-by-wire: system & design requirements steer-by-wire, brake-by-wire, suspension-by-wire, gas-by-wire, power-by wire, shift by-wire. Future of Automotive Electronics.

Module-3

Hardware Modules:
MC9S12XD family features-Modes of operation-functional block diagram overview-programming model. Memory Map Overview Pulse Width Modulator (PWM)-On-chip ADC Serial Communication Protocol: SCI, SPI, IIC, CAN.

Module-4

Software Development Tools:
Introduction to HCS12XDT512 Student Learning Kit & PBMCU (Project Board) –Introduction to Code Warrior IDE-Editing- Debugging-Simulating simple programs. Flashing code into HCS12XDT512 SLK board and testing

Module-5

Integration of Software and Hardware:
Downloading the Software from Host Machine to Target Machine. Implementing application prototype: Power Window and Automotive Lighting System

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Technical Information Technologies and characteristic data	Werner Klingenstein	Publicis Corporate Publishing, 2nd revised edition	2004
2	Automotive Electronics Handbook	Ronald K Jurgen	McGraw Hill, 2nd edition	1999
3	Technical Information, Technologies and Characteristic Data	Werner Klingenstein & Team	Publicis Corporate Publishing 2nd	2004
4	Intelligent Vehicle Technologies: Theory and Applications Butterworth	Ljubo Vlacic, Michel Parent & Furnio Harshima	Heinemann publications	2001

(Group-5): **Course Code :** 20MAU322

Course Title: INDUSTRY 4.0 AND IIOT IN AUTOMOTIVE VEHICLES

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

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

Module-2

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

Module-3

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

Module-4

IIoT Application Development : Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices

Module-5

Case Studies: IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Internet of Things	Arshdeep Bahga, Vijay Madisetti	A Hands on Approach University Press 1st Edition	2015
2	The Internet of Things: Enabling Technologies, Platforms, and Use Cases	Pethuru Raj and Anupama C. Raman	CRC Press, 1st Edition	2017
3	Introduction to Internet of Things	SRN Reddy, Rachit Thukral and Manasi Mishra	A practical Approach ETI Labs, Edition	2017
4	Designing the Internet of Things	Adrian McEwen	Wiley 1st Edition	2013.
5	Internet of Things : Architecture and Design	Raj Kamal	McGraw Hill 1st Edition	2017

(Group-5): **Course Code :** 20MAU323

Course Title: ADVANCED MANUFACTURING TECHNOLOGY

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Sheet Metal Forming:
Introduction, Forming methods, shearing and Blanking, Bending, stretch forming, Deep drawing, redrawing operations, Defects in formed products.

High Energy Rate Forming:
Explosive forming, Electro-hydraulic forming, Electro-magnetic forming, Super Plastic Forming - Process principles, Equipment, Process variables, Merits and Limitations

Module-2

Forging:
Classification, various stages during forging, Forging equipment, brief description, deformation in compression, forging defects. Residual stresses in forging.

Special Casting processes:
Different casting techniques for manufacturing of automotive components like cylinder block, piston, flywheel, bearing liners, etc.

Joining of Plastics:
Heated tool welding or hot bar welding, Hot gas welding or pendulum welding, High frequency welding, Ultrasonic welding, Friction welding, Induction welding

Module-3

Powder Metallurgy Processing:
Process details and special characteristics of Powder Metallurgy process, Powder making methods, Characteristics of Powders, Process flow chart, Process steps and Process variables.
Compaction techniques like CIP & HIP (Cold Iso-static and Hot Iso-static pressing), Product design considerations, Applications of Powder metallurgy

Module-4

Agile Manufacturing Technologies: Introduction, Developing agile manufacturing, Integration of Product/Process Development, Application of IT/IS concepts, Agile supply chain management, Design of skill and knowledge and Computer control of Agile manufacturing. Flexible manufacturing systems

Module-5

Plastics Injection Mould Design : General arrangement of an injection mould, Basic systems of the mould – Feeding system, cooling system and ejection systems, Concepts of three plate molds and tooling for moulding articles with undercuts, Concepts of split moulds, hot runner systems-Their advantages and limitation over conventional systems. Basic concepts of mould standardization and innovative mould components

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Fundamentals of Working of Metals	Sach G.	Pergamum Press 2nd Edition	2008
2	Engineering Materials & their applications	R. A. Flinn & P. K. Trojan	4th edition, Jaico Publishing House 1stEdition	1999
3	High speed combustion engines	P.M. Heldt	Oxford and IBH Publishing Co, New York 2nd Edition	1990

4	Agile Manufacturing The 21st Century Competitive strategy	A Gunasekharan	Elsevier Press, India 1st Edition	2001
5	Rapid Manufacturing	Flham D.T &Dinjoy	S.S Verlog London 2nd Edition	2001

(Group-5): **Course Code : 20MAU334**

Course Title: AUTOMOTIVE MATERIALS

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Aluminium Alloys & Lightweight Magnesium for Automotive Applications: Introduction; Wrought aluminium alloys; Cast aluminium processes Technologies; Cast aluminium metallurgy and properties; New Lightweight alloys; Process technologies; mechanical and physical properties; Case studies of applications.

Testing Automotive Materials:
Evaluation of materials under realistic loading and environmental conditions; different test methods for evaluation of properties for specific applications.

Module-2

Composite Materials for Automotive Applications:
Definition, Classification, Types of matrices & reinforcements, characteristics & selection, Fiber composites, laminated composites, particulate composites, prepegs, sandwich construction.

Manufacturing Composite Materials:
Layup and curing-open and closed mould processing-Hand lay-up techniques-Bag moulding and filament winding. Pultrusion, pulforming, Thermoforming, Injection moulding, Cutting, Machining and joining, tooling, Quality assurance-Introduction, material qualification, types of defects, NDT methods.

Module-3

Metal Matrix Composites:
Reinforcement materials, types, Characteristics & selection, base metals, selection, applications in automotive engineering

Module-4

Micro Mechanical analysis of a Lamina:
Introduction, Evaluation of the four elastic modules – Rule of mixture, ultimate strengths of unidirectional lamina.

Macro mechanics of a Lamina:
Hooke's law for different types of materials, number of elastic constants; Two – dimensional relationship of compliance & stiffness matrix. Hooke's law for two dimensional angle lamina, engineering constants - angle lamina, Invariants, Theories of failure.

Module-5

Macro Mechanics of Laminates:
Laminates Coding, ABD Matrices, Classical Laminates Theory, Special cases of Laminates, Strength Theories of Laminates.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Developments in Lightweight Alloys for Automotive Applications	James M Boileau	SAE, 1st Edition	2006
2	Lightweight Magnesium Technology	Thomes Ruden	SAE illustrated Edition	2006
3	Testing Automotive Materials & Components	Donald H Wright	SAE 1st Edition	1993
4	Composite material science and Engineering	Krishan K. Chawla	Springer, 3rd Edition	2012

5	Fibre reinforced composites	P. C. Mallik, Marcel Decker	3rd Edition	2007

(Group-5):	**Course Code : 20MTP241**
Course Title: ENERGY CONSERVATION AND MANAGEMENT	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Energy Conservation: Introduction - Indian Energy Conservation Act - List of Energy Intensive Industries - Rules for Efficient Energy Conservation - Identification of Energy Conservation opportunities - Technologies for Energy Conservation – Energy Conservation Schemes and Measures - Energy flow networks - Critical assessment of energy use - Optimizing Energy Inputs and Energy Balance - Pinch Technology.

Module-2

Energy Efficiency Improvement: Steam Generation - Distribution and Utilization - Furnaces - Fans and Blowers - Compressors Pumps - Pinch Technology - Fluidized bed Combustion - Heat Exchanger Networks - Case Studies - Analysis and recommendation.

Module-3

Energy Audit: Definition and Concepts, Types of Energy Audits – Basic Energy Concepts - Energy audit questionnaire, Data Gathering – Analytical Techniques. Energy Consultant: Need of Energy Consultant – Consultant Selection Criteria, Economic Analysis: Scope, Characterization of an Investment Project – Types of Depreciation –Time Value of money – budget considerations, Risk Analysis. Introduction to SCADA software.

Module-4

Energy Efficient Lighting: Terminology - Laws of illumination - Types of lamps -Characteristics - Design of illumination systems - Good lighting practice - Lighting control- Steps for lighting energy conservation. Lighting standards.

Module-5

Economics of Generation and Distribution: Generation: Definitions - Connected load, Maximum demand - Demand factor –Diversity factor – Significance - Power Factor – Causes and disadvantages of low power factor – Economics of power factor improvement. Distribution: Electrical load analysis - Types of consumers & tariffs - Line losses -Corona losses - Types of distribution system - Kelvin's law - Loss load factor – Green Labeling – Star Rating.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/ Textbooks

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

(Group-5):	**Course Code :** 20MMD33
Course Title: SMART MATERIALS AND STRUCTURES	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Smart Structures: Types of smart structures, potential feasibility of smart structures, key elements of smart structures, applications of smart structures. Piezoelectric materials, properties, piezoelectric constitutive relations, depoling and coersive field, field strain relation. Hysteresis, creep and strain rate effects, inchworm linear motor. Beam modelling: Beam modelling with induced strain rate effects, inchworm linear motor beam modelling with induced strain actuation-single actuators, dual actuators, pure extension, pure bending harmonic excitation, Bernoulli-Euler beam model, problems, piezo-electrical applications.

Module-2

Shape memory Alloy: Experimental phenomenology, shape memory effect, phase transformation, Tanaka's constitutive model, testing of SMA wires, vibration control through SMA, multiplexing. Applications of SMA and problems. ER and MR fluids: Mechanisms and properties, fluid composition and behaviour, the Bingham plastic and related models, pre-yield response, post-yield flow applications in clutches, dampers and others.

Module-3

Vibration absorbers: Series and parallel damped vibrations (overview), active vibration absorbers, fiber optics, physical phenomena, characteristics, sensors, fiber optics in crack detection, applications. Control of structures: Modelling, control strategies and limitations, active structures in practice.

Module-4

MEMS: Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration.

Module-5

Devices: Sensors and Actuators, conductivity of Semiconductors, crystal planes and orientation, Stress and Strain Relations, Flexural Beam Bending Analysis under simple loading conditions, polymers in MEMS, optical MEMS applications.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/ Textbooks

1. Smart Materials and Structures - M. V. Gandhi and B. So Thompson, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).
2. Smart Structures and Materials - B. Culshaw, Artech House, Boston, 1996 (ISBN: 0890066817).
3. Smart Structures: Analysis and Design - A. V. Srinivasan, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267

Reference Books

1. Electro ceramics: Materials, Properties and Applications - A. J. Moulson and J. M. Herbert. John Wiley & Sons, ISBN: 0471497429
2. Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York, 2002 (ISBN: 3540422595).
3. Piezoelectric Actuators and Wtrasonic Motors - K. Uchino, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114).
4. Handbook of Giant Magnetostrictive Materials - G. Engdahl, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).
5. Shape Memory Materials - K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York, 199~ (ISBN: 052144487X).

(Group-5): **Course Code :** 20MST323

Course Title: NON-TRADITIONAL MACHINING

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction: Need for non-traditional machining processes, Process selection, classification, comparative study of different processes. Ultra-Sonic Machining: Definition, Mechanism of metal removal, elements of the process, Tool feed mechanisms, Theories of mechanics, effect of parameters, Different types of concentrators, horn design, applications, Limitations. Abrasive Jet Machining: Principle, Process parameters, Influence of process parameters on MRR, applications, advantages and disadvantages. Water Jet Machining: Principle, Equipment, Operation, Application, Advantages and limitations of water Jet machinery.

Module-2

Thermal Metal Removal Processes: Electric discharge machining, Principle of operation, mechanism of metal removal, basic EDM circuitry, spark erosion generators, Analysis of relaxation type of circuit, material, removal rate in relaxation circuits, critical resistance parameters in Ro Circuit, Die electric fluids, Electrodes for spark erosion- surface finish, applications. Electro Chemical machining (ECM): Classification of ECM process, Principle of ECM, Chemistry of the ECM process, parameters of the process, Determination of the metal removal rate, dynamics of ECM process, Hydrodynamics of ECM process, polarization, Tool Design, advantages and disadvantages-applications. Electro Chemical grinding, Electro Chemical honing and Electrochemical deburring.

Module-3

Chemical Machining: Introduction, fundamental principle types of chemical machining, Maskants, Etchants, Advantages and disadvantages, applications, chemical blanking, chemical milling (contour machining), Hydrogen embrittlement. Plasma arc Machining: Introduction, Plasma, Generation of Plasma and equipment, Mechanism of metals removal, PAM parameters, process characteristics, types of torches, applications. Electron beam machining (EBM): Introduction, Equipment for production of Electron beam, Theory of electron beam machining, Thermal & Non thermal type, Process characteristics, applications.

Module-4

Laser Beam Machining: Introduction, principles of generation of lasers, Equipment and Machining Procedure, Types of Lasers, Process characteristics, advantages and limitations, applications of laser beam machining. CO2 Laser: Principle, Equipment, Applications. Ion Beam Machining: principle, equipment, working, sputtering rate, applications.

Module-5

High Velocity forming processes: Introduction, development of specific process, selection, comparison of conventional and high velocity forming methods. Types of high velocity forming methods: explosion forming process, electro-hydraulics forming, magnetic pulse forming. Applications, Advantages and limitations.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/ Textbooks

1. Modern Machining Process - P.C Pandey & H.S Shan Tata Mc Graw Hill.
2. Modern Machining Processes - P.K Mishra, Paperback – Import, 30 Jan 1997, Narosa publishers.
3.Thermal Metal Cutting Processes - Dr. B. J. Ranganatha, I K International, New Delhi

Reference Books

1. New technology - Bhattacharya, Institution of Engineers, India
2. Production technology - HMT Tata Mc Graw Hill.
3. Metals hand book - ASM Vol-3.
4. High velocity forming of metals - F.M Wilson ASTME PrenticeHall.
5. Modern Manufacturing Methods - Adithan

(Group-5):	**Course Code : 20MAR251**
Course Title: NETWORKING AND IoT	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**
Module-1	
Introduction to IoT Defining IoT, Characteristics of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT, Communication models &APIs. **IoT & M2M** Machine to Machine, Difference between IoT and M2M, Software define Network	
Module-2	
Network & Communication aspects Wireless medium access issues, MAC protocol survey, Survey routing protocols, Sensor deployment & Node discovery, Data aggregation & dissemination.	
Module-3	
Challenges in IoT Design challenges, Development challenges, Security challenges, Other challenges.	
Module-4	
Domain specific applications of IoT Home automation, Industry applications, Surveillance applications, Other IoT applications.	
Module-5	
Developing IoTs Introduction to Python, Introduction to different IoT tools, Developing applications through IoT tools, Developing sensor based application through embedded system platform, Implementing IoT concepts with python.	
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module.	
Textbook/ Textbooks	
(1) IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things. by David Hanes, Cisco Press,2007	
(2) Vijay Madisetti, Arshdeep Bahga, "Internet of Things: A Hands - On Approach"	
Reference Books	
(1) Computer Networks; By: Tanenbaum, Andrew S; Pearson Education Pte. Ltd., Delhi, 4th Edition 6	
(2) Waltenegus Dargie, Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice	
(3) Data and Computer Communications; By: Stallings, William; Pearson Education Pte. Ltd., Delhi, 6th Edition	

(Group-5):	**Course Code : 20MTP324**
Course Title: PHASE CHANGE PHENOMENA IN FLUIDS	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**
Module-1	
Fundamentals: Thermodynamic Equilibrium of Binary and Multi-component mixtures: Fugacity and Fugacity Coefficient of Pure Substance and Mixture, Gibbs Phase Rule. **Binary Mixtures:** Phase Equilibrium Diagrams for Binary Mixtures, Ideal Mixtures, Numerical on phase diagrams of ideal mixtures, Raoult's law of mixture, Zeoptrope and Azoetrope mixture Basic Equations on two phase flow: Mass, Momentum and Energy.	
Module-2	
Pool Boiling: Boiling regimes, Dimensional Analysis, Nucleate boiling of ordinary fluids, Numerical on nucleate boiling, Film boiling of ordinary fluids, Passive and Active enhancement techniques in heat transfer enhancement.	
Module-3	
Flow boiling: Boiling regimes in Horizontal and vertical flow, Nucleate boiling in flow, Saturated boiling in flow, Film boiling in flow, Flow boiling for binary mixtures and Augmentation techniques inflow boiling.	
Module-4	
Flow Patterns and Bubble Dynamics: Flow pattern in Horizontal and vertical tubes: Bubbly flow, plug flow, Stratified flow, Wavy flow, Slug flow and Annular flow. Two phase flow instability: Taylor and Helmholtz instabilities Homogenous and Heterogeneous Nucleation, Rayleigh-Plesset Equation, Bubble Nucleation site density, Bubble size, Bubble departure, Bubble waiting period, Bubble departure and Simple Numerical.	
Module-5	
Condensation: Film wise condensation: Laminar condensation of vapour, Condensation on tube banks and Numerical. Drop wise Condensation: Condensation of steam-Factors effecting.	
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module. module module.	
Textbook/ Textbooks	
1. Convective boiling and condensation by John G. Collier and John R. Thome, Third edition, Oxford Science Publication.	
2. Boiling heat transfer and Multiphase flow by L.S Tong, Second edition, Taylor and Francis Publication.	
3. Hand book of Phase Change in Boiling and Condensation by Sathish G. Kandlikar by Taylor and Francis	
Reference Books	
1. Fundamentals of Multiphase Flows by Christopher E. Brennen, Cambridge University Press 2005.	
E Books/Web references	
1. https://nptel.ac.in/courses/103105058/ 2. https://nptel.ac.in/courses/112107207/	

(Group-5): **Course Code :** 20MTE251

Course Title: PRODUCT DESIGN TECHNOLOGY

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction: Characteristics of successful product development who Designs and develops products, duration and cost of product development, the challenges of product development.
Development Processes and Organizations: A generic development process, concept development; the front-end process, adapting the generic product development process, the AMF development process, product development organizations, the AMF organization.

Module-2

Product Planning: The product planning process, identify opportunities, Evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning, reflect all the results and the process.
Identifying Customer Needs: Gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into a hierarchy, establish the relative importance of needs and reflect on the results and the process.
Product Specifications: What are specifications, when are specifications established, establishing target specifications setting the final specifications.
Concept Selection: Overview of methodology, concept screening, concept scoring, caveats.

Module-3

Concept Testing: Define the purpose of concept test, choose a survey population, choose a survey format, communicate the concept, measure customer response, interpret the result and reflect on the results and the process.

Product Architecture: What is product architecture, implications of the architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues

Module-4

Industrial Design: Assessing the need for industrial design, the impact of industrial design, industrial design process, managing the industrial design process assessing the quality of industrial design.
Design for Manufacturing: Definition, estimation of manufacturing cost, reducing the cost of components assembly, supporting production, impact the DFM on other factors.

Module-5

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/ Textbooks

1. Product Design and Development, Karl,. T. Ulrich, Steven D. Eppinger, Irwin McGraw Hill.
2. Product Design for Manufacture and Assembly, Geoffery Boothroyd, Peter Dewhurst and Winston

Reference Books

1. Product Design and Manufacturing, A C Chitale and R C Gupta, PH1.
2. New Product Development, Timjones Butterworth Heinmann, Oxford, UCI.1997.

Ph.D Coursework Courses under Group - 6			
SlNo	**Course Code**	**Course Name**	**Page**
1	20MAU243	Automotive control systems	83
2	20MAU331	Machine Learning	85
3	20MAU332	Artificial Intelligence	86
4	20MTP253	Computational methods in Heat transfer and fluid Flow	87
5	20MTP322	Theory of I.C Engine	89
6	20MTP334	Thermal storage system	90
7	20MMD333	Design of hydraulic and pneumatic system	91
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9	20MMD324	Experimental Mechanics	93
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(Group-6): **Course Code : 20MAU243**

Course Title :AUTOMOTIVE CONTROL SYSTEMS

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Chassis and Drive Line Control:
Components of chassis management system – role of various sensors and actuators pertaining to chassis system – construction – working principle of wheel speed sensor, steering position, tyre pressure, brake pressure, steering torque, fuel level, Engine and vehicle design data

Drive Line Control:
Speed control - cylinder cut - off technology, Gear shifting control – Traction / braking control, brake by wire - Adaptive cruise control, throttle by wire. Steering - power steering, collapsible and tiltable steering column, steer by wire

Module-2

Engine Management System:
Basic Engine Operations – Fuel Control, Ignition control, Lambda Control, Idle Speed Control, Knock Control , Open Loop and Closed Loop Control

Sensors:
Basic sensor arrangement; Types of sensors such as oxygen sensors, Crank angle position sensors, fuel metering/vehicle speed sensors and detonation sensors, altitude sensors, flow sensors, throttle position sensors, solenoids.

Module-3

Safety and Security Systems: Airbags, seat belt tightening system, collision warning systems, child Lock, anti-lock braking systems, Vision enhancement - Static and dynamic bending of Head light, road recognition system, Anti-theft technologies, smart card system, number plate coding, central locking system.

Module-4

Comfort and Vehicle Control System:
Active suspension systems, requirement and characteristics, different types, Vehicle Handling and Ride characteristics of road vehicle, pitch, yaw, bounce control, power windows, adaptive noise control. ABS Control System – Torque Balance at Wheels road contact – Control cycle of ABS System – Advantages – Traction control system- Combination of ABS with Traction control system

Module-5

Intelligent Transportation System:
Traffic routing system - Automated highway systems - Lane warning system - Driver Information System, driver assistance systems - Data communication within the car, Driver conditioning warning - Route Guidance and Navigation Systems-vision enhancement system, In-Vehicle Computing-Vehicle Diagnostics system. VANET usage in Automobiles

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Automotive Control Systems	U. Kiencke, L. Nielsen	SAE and Springer-Verlag	
2	Intelligent Vehicle Technologies	Ljubo Vlacic, Michel Parent, Fumio	Butterworth - Heinemann publications, Oxford	

3	Automotive Mechanics,	W.H. &Anglin, D.L	Intl. Student edition, , TMH, New Delhi 9th edition	2002
4	Understanding Automotive Electronics	William B.Ribbens	Butter worth, Heinemann Woburn, 5th edition	1998
5	Automotive Hand Book	Bosch	SAE 8th edition	2007

(Group-6): **Course Code : 20MAU331**

Course Title: MACHINE LEARNING

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction: Well posed learning problems, Designing a Learning system, Perspective and Issues in Machine Learning.

Concept Learning: Concept learning task, Concept learning as search, Find-S algorithm, Version space, Candidate Elimination algorithm, Inductive Bias.

Module-2

Decision Tree Learning: Decision tree representation, Appropriate problems for decision tree learning, Basic decision tree learning algorithm, hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning

Module-3

Artificial Neural Networks: Introduction, Neural Network representation, Appropriate problems, Perceptrons, Back propagation algorithm

Module-4

Bayesian Learning: Introduction, Bayes theorem, Bayes theorem and concept learning, ML and LS error hypothesis, ML for predicting probabilities, MDL principle, Naive Bayes classifier, Bayesian belief networks, EM algorithm

Module-5

Evaluating Hypothesis: Motivation, Estimating hypothesis accuracy, Basics of sampling theorem, General approach for deriving confidence intervals, Difference in error of two hypotheses, Comparing learning algorithms.

Instance Based Learning: Introduction, k-nearest neighbour learning, locally weighted regression, radial basis function, cased-based reasoning,

Reinforcement Learning: Introduction, Learning Task, Q Learning

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module. ■

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Machine Learning	Tom M. Mitchell	McGraw Hill Education. India Edition	2013
2	Machine Learning For Absolute Beginners	Oliver Theobald	A Plain English Introduction Scatter plot Press 2nd Edition	2013
3	The Elements of Statistical Learning Springer series in statistics	Trevor Hastie, Robert Tibshirani, Jerome	Springer	
4	Machine Learning: The Ultimate Guide for Beginners and Starters	Andy Grey	Amazon Asia-Pacific Holdings Private Limited, Kindle Edition	
5	Introduction to machine learning	Ethem Alpaydın	MIT press. 3rd Edition	2014

(Group-6):	**Course Code : 20MAU332**
Course Title: ARTIFICIAL INTELLIGENCE	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction: Overview of AI problems, examples of successful recent AI applications. The Turing test, Rational versus non-rational reasoning.
Search Strategies: Problem spaces (states, goals and operators), problem solving by search. Uninformed search (breadth-first, depth-first, depth first with iterative deepening). Heuristics and informed search (hill-climbing, generic best-first, A*). Minimax Search, Alpha-beta pruning

Module-2

Knowledge representation and reasoning: Review of propositional and predicate logic, First order logic, Resolution and theorem proving, Forward chaining, Backward chaining, Temporal and spatial reasoning. Review of probabilistic reasoning, Bayes theorem. Totally-ordered and partially-ordered Planning

Module-3

Planning-The blocks world, Components of Planning Systems, Goal stack planning, Nonlinear planning, Hierarchical planning. Learning-Learning from example, Learning by advice, Explanation based learning, Learning in problem solving, Definition and examples of broad variety of machine learning tasks, Classification, Inductive learning, Simple statistical-based learning such as Naive Bayesian Classifier, decision trees.

Module-4

Natural Language Processing: Language models, n-grams, Vector space models, Bag of words, Text classification, Information retrieval, Pagerank, Information extraction, Question-answering

Module-5

Agents: Definition of agents, Agent architectures (e.g., reactive, layered, cognitive), Multi-agent systems-Collaborating agents, Competitive agents, Swarm systems and biologically inspired models. Expert Systems: Representing and Using Domain Knowledge, Expert System Shells, Explanation, Knowledge Acquisition

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/Reference Books

	Title of the book	**Author Name**	**Publisher's Name**	**Publication year**
1	Artificial Intelligence Tata	Elaine Rich, Kevin Knight and Shivashankar Nair	Tata McGraw Hill 3rd Edition	2009
2	Introduction to Artificial Intelligence and Expert Systems	Dan W. Patterson	Pearson Education1st Edition	2015
3	Artificial Intelligence	S. Russell and P. Norvig	Modern Approach Prentice Hall, 3rd Edition	2009
4	Artificial Intelligence: A Guide for Thinking Humans Farrar	Melanie Mitchel	Straus and Giroux , 1st Edition	2019
5	Artificial Intelligence: Principles and Applications	Masoud Yazdani	Chapman and Hall, 1986 Digital Edition	2008

(Group-6):	**Course Code: 20MTP253**
Course Title: COMPUTATIONAL METHODS IN HEAT TRANSFER & FLUID FLOW	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Programming fundamentals, MATLAB programming, Numerical Methods. Governing equations of fluid dynamics: Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching.

Module-2

Mathematical behavior of partial differential equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations. **Basic aspects of discretization**: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, Uniform and unequally spaced grid points. **Grids with appropriate transformation**: General transformation of the equations, Metrics and Jacobians, The transformed governing equations of the CFD, Boundary fitted coordinate systems, Algebraic and elliptic grid generation techniques, Adaptive grids.

Module-3

Parabolic partial differential equations: Finite difference formulations, Explicit methods – FTCS, Richardson and DuFort-Frankel methods, Implicit methods - Laasonen, Crank-Nicolson and Beta formulation methods, Approximate factorization, Fractional step methods, Consistency analysis, Linearization**. Stability analysis**: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, artificial dissipation and dispersion.

Module-4

Elliptic equations: Finite difference formulation, solution algorithms: Jacobi -iteration method, a Gauss-Siedel iteration method, point- and line-successive over-relaxation methods, and alternative direction implicit methods. **Hyperbolic equations**: Explicit and implicit finite difference formulations, splitting methods, multi-step methods, applications to linear and nonlinear problems, linear damping, flux corrected transport, monotone and total variation diminishing schemes, tvd formulations, entropy condition, first-order and second-order tvd schemes.

Module-5

Scalar representation of Navier-stokes equations: Equations of fluid motion, numerical algorithms: FTCS explicit, FTBCS explicit, Dufort-Frankel explicit, Maccormack explicit and implicit, BTCS and BTBCs implicit algorithms, applications. **Grid generation:** Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation. **Finite volume method for unstructured grids:** Advantages, Cell Centered and Nodal point Approaches, Solution of Generic Equation with tetrahedral Elements, 2-D Heat conduction with Triangular Elements Numerical solution of quasi one-dimensional nozzle flow: Subsonic-Supersonic isentropic flow, Governing equations for Quasi 1-D flow, Non-dimensionalizing the equations, Mac Cormack technique of discretization, Stability condition, Boundary conditions, Solution for shock flows

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/ Textbooks

1. Numerical Heat Transfer and Fluid Flow - S.V. Patankar, Hemisphere Publishing Company.
2. Computational Fluid Dynamics - T.J. Chung, Cambridge University Press 2003
3. Computational fluid flow and heat transfer - K. Murlidhar and T. Sounderrajan, Narosa Publishing Co.
4. Computational fluid mechanics and heat transfer - D. A. Anderson, J. C. Tannehill, R.H. Pletcher, Tata McGraw-Hill Publications 2002

5. Computational fluid dynamics - J.A. Anderson, McGraw-Hill Publications 1995
6. An Introduction to Computational Fluid Dynamics Versteeg, H.K. and Malalasekara, W, Pearson Education, 2010

(Group-6):	**Course Code : 20MTP322**
Course Title : THEORY OF IC ENGINES	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction to IC Engines: Basic engine components and nomenclature ,Applications of IC Engines**,** Engine characteristics, geometrical properties of reciprocating engines, specific emissions and emission index, relationships between performance parameters, Engine design and performance data. Energy flow through IC engines, Various Auxiliary systems. Environment friendly engines. Fuel –Air and Actual Engines: Modeling of Fuel-Air cycle Effect of operating variables on the performance of Fuel –air Cycles, Detailed analysis of difference between Fuel-Air and Real Cycle, Combustion charts and Gas Tables.

Module-2

Carburetion: Introduction, Factors affecting carburetion, mixture requirements at different load and speed, principles of carburetion, essential parts and functions of a carburetor, compensating devices, Modern Carburetors, Altitude compensation devices, Injection in SI engine. **Injection Systems:** Introduction to Mechanical Injection System, Functional Requirements and classification, Fuel feed pump and Fuel Injector, **Electronic injection systems:** Types, Merits and Demerits, Multi point fuel injection system (MPFI), Electronic control system, Injection timings, Common-Rail Fuel Injection System.

Module-3

Modeling of IC Engines : Governing Equation for open thermodynamic systems, intake and exhaust flow models, Thermodynamic based in cylinder models, Direct-injection CI engine models, Combustion models, Fluid Mechanics based multi-dimensional models.

Module-4

Engine emissions and their control: Air pollution due to IC engines, emission characteristics, Euro norms, engine emissions, Hydro carbon emissions, CO emission, NOx- Photo chemical smog, Particulates, other emissions, Smoke, emission control methods – thermal converters, catalytic converters, particulate traps, Ammonia injection systems, exhaust gas recirculation, ELCD, Crank case blow by control. IC engine Noise characteristics, types, standards and control methods, Air quality emission standards **Measurement:** Noise, Emission, Pressure, crank angle torque, valve timings, temperature and flow measurements

Module-5

Alternate fuels for IC engines: Vegetable oils, alcohol, LPG, CNG, Hydrogen fuels, Bio gas, Dual fuels, other possible fuels Case studies: The rover K series engine, Chrysler 2.3 liter SI engine, Ford 2, 5 Liter DI Diesel Engine.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/ Textbooks

1. V. Ganesan, "Internal Combustion Engines", Tata McGraw-Hill Publications, 4th Edition.
2. John B Heywood, "IC Engines fundamentals", McGraw- Hill Publications, 2011.
3. C R Fergusan, "Internal Combustion Engines: Applied Thermo sciences", John Wiley & Sons.
4. Richard stone ''Introduction to IC Engines'' Palgrave Publication 3rd edition.
5. Charles Fayette Taylor '' The Internal-Combustion Engine in Theory and Practice'' MIT Press 2nd edition.

(Group-6):	**Course Code : 20MTP334**
Course Title : THERMAL STORAGE SYSTEM	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction: Need of Energy Storage, Different modes of Energy Storage, Necessity of thermal storage, Thermal Storage Devices, Areas of Applications of thermal Storage, Heat Transfer Enhancement Methods.

Module-2

Sensible Heat Storage system: Basic concept, Modeling of storage System, Water and rock bed storage-use of TRANSYS, Pressurized water storage in power plant, Packed bed storage, Stratified storage systems, Thermal storage in buildings, Earth storage, Energy storage in aquifers, Heat storage in SHS systems, Aquifers storage. Chemical Energy Storage, Thermo-Chemical, Bio-Chemical, Electro-Chemical, Fossil fuels and synthetic fuels and Hydrogen storage.

Module-3

Regenerator: Parallel Flow, Counter Flow, Finite conductivity model, Non-linear Model, Transient Performance, Step Change in inlet gas temperature, Step Change in inlet gas Flow rate, Parameterization of Transient Response, Heat Storage exchangers

Module-4

Latent Heat Storage: Storage material modeling of phase change problem, Enthalpy Modeling, Heat Transfer Enhancement Configuration, Parameterization of Rectangular, Cylindrical Geometric Problems, Phase Change Materials(PCMs), Selection Criteria Of PCMs, Stefan Problem, Solar Thermal LHTES Systems, Energy Conservation Through LHTES Systems, LHTES Systems in Refrigeration and Air Conditioning Systems.

Module-5

Applications of Thermal Storage System: Food storage, Waste heat recovery, Solar energy storage, Green house heating, Drying and heating applications, Power Plant Applications, Drying and Heating for Process Industries

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/ Textbooks

1. F. W. Schmidt and A.J. Willimot, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.

2. V J Liunardini, Heat Transfer in Cold Climate, D Van Nostrand Reinhold, NY, 1981.

3. Ibrahim Dincer and Marc A. Rosen, Thermal Energy Storage System and Applications.

(Group-6):	**Course Code : 20MMD333**
Course Title : DESIGN OF HYDRAULIC & PNEUMATIC SYSTEMS	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction to Hydraulic System: Introduction, Basic hydraulic system, classification of hydraulic motors, hydraulic pumps, Performance of hydraulic motors, Hydraulic actuators, types of hydraulic actuators. Control Components in Hydraulic Systems: Introduction, Direction control valves, Solenoid actuated valve, Pilot operated valve, Rotary spool DCV, Pressure control valves, Hydraulic fuse, Flow control valve, graphic symbols.

Module-2

Maintenance of Hydraulic Systems: Prime function of hydraulic fluids, desirable properties of hydraulic fluids, general types of fluids, factors affecting the selection of fluids, sealing devices, reservoir systems, filters and strainers, heat exchangers, pressure switch, wear of moving parts, troubleshooting of hydraulic systems.

Module-3

Hydraulic circuit Design and Analysis: Control of a single acting cylinder, double acting cylinder, regenerative circuit, counter balance valve applications, Hydraulic cylinder sequencing circuits, automatic cylinder reciprocating systems, Locked cylinder using pilot check valves, cylinder synchronizing circuits, fail safe circuits.

Module-4

Pneumatic Concepts: Introduction, comparison of hydraulics/pneumatics/and electrical system, air compressor system, types of compressors, compressed air behaviour, pneumatic actuators, direction control valves, building a pneumatic circuits, application of logic valves. Design of Pneumatic Circuits: Speed control circuits, Application of time delay valves. Position sensing in pneumatic cylinders, roller lever valve, pressure sensing in pneumatic circuits, pressure sequence valve, two cylinder movement, cascade method.

Module-5

Electro-Pneumatics: Introduction, Pilot operated solenoid valve, Electrical connection to the solenoid, Electro-pneumatic circuit, Electrical limit switches and proximity switches, Relays, Solenoid, PE converter, Concept of latching. Servo System and PLC Applications in Pneumatics: Closed loop control with servo system, Hydro-mechanical servo system, Electro-hydraulic servo system, Conventional valve vs proportional valve, Proportional valve in hydraulic circuits, characteristics of proportional valve and servo valve. PLC application in fluid power, logic in ladder logic diagram and Mnemonics, Timer- on delay and off delay

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbooks/ Reference Books

1. S Ilango, V Soundararajan, Introduction to Hydraulics and Pneumatics, PHI Publication, ISBN- 978-81-203-3079-5.
2. Jagadeesha T, Hydraulics and Pneumatics, I K International Publication, ISBN: 978-93-84588- 90-8
3. James L Johnson, Introduction to fluid power, Cengage Learning, first edition 2003, ISBN- 981- 243-661-8
4. R Srinivasan, Hydraulic and pneumatic controls, Tata McGraw hill, second edition, 2010, ISBN – 978-81-8209-138-2.

(Group-6):	**Course Code : 20CAE253**
Course Title : DESIGN OF MICRO ELECTRO MECHANICAL SYSTEMS	
Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Introduction: Micro Electro-Mechanical Systems, Ultra Precision Engineering, Micro-sensors; Micro-actuators; Microelectronics Fabrication; Micromachining; Mechanical MEMS; Thermal MEMS, MOEMS, Magnetic MEMS, RF MEMS, Micro-fluidic Systems, Bio and Chemo Devices.

Module-2

Micro fabrication and Micromachining: Integrated Circuit Processes, Bulk Micromachining: Isotropic Etching and Anisotropic Etching, Wafer Bonding.
Mechanical Sensors and Actuators: Principles of Sensing and Actuation; Beam and Cantilever; Micro plates; Capacitive Effects; Piezoelectric material as Sensing and Actuating Elements, Strain Measurement, Pressure measurement

Module-3

Thermal and Fluidic Micro Sensors and Actuators : Thermal sensors, Electrical Sensors, Chemical and Biosensors Electromagnetic and Thermal micro actuation, Mechanical design of micro actuators, Micro actuator examples, Micro Fluidic systems, Fluid actuation methods, micro valves, micro pumps, micro motors-Micro actuator systems.

Module-4

Surface Micromachining: One or two sacrificial layer processes, Surface micro machining requirements, Polysilicon surface micromachining, Other compatible materials, Silicon Dioxide, Silicon Nitride, Piezoelectric materials.

Module-5

MEMS: Characterization: Technologies for MEMS characterization, Scanning Probe Microscopy (SPM): Atomic Force Microscopy (AFM), Scanning tunnelling microscopy (STM), Magnetic Force Microscopy, Scanning Electron Microscope.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/ Textbooks

1. Rai - Choudhury P. MEMS and MOEMS Technology and Applications, PHI Learning Private Limited, 2009.
2. Stephen D. Senturia, "Microsystem Design" Springer, 2001.
3. MarcMadou, “Fundamentals of Microfabrication” Taylor & Francis Group, 2002.
4. Gregory Kovacs, “Micromachined Transducers Source book” McGraw Hill 1998.

Reference Books

1. M.H. Bao, “Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes” Handbook, Elsevier.
2. Nadim Maluf, An Introduction to Micro electromechanical Systems Engineering, Artech House Publishers, 2000.
3. Stephen D. Senturia, "Microsystems Design" Kluwer Academic Publishers, New York.

(Group-6):	**Course Code : 20MMD324**
Course Title : EXPERIMENTAL MECHANICS	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction: Definition of terms, calibration, standards, dimensions and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning.

Analysis of Experimental Data: Cause and types of experimental errors, error analysis. Statistical analysis of experimental data-pprobability distribution, Gaussian, Normal distribution. Chi-square test, method of least square, correlation coefficient, multivariable regression, standard deviation of mean, graphical analysis and curve fitting, general consideration in data analysis.

Module-2

Data Acquisition and Processing: General data acquisition system, signal conditioning revisited, data transmission, Analog-to-Digital and Digital-to- Analog conversion. Basic components (storage and display) of data acquisition system. Computer program as a substitute for wired logic.

Force, Torque and Strain Measurement: Mass balance measurement, elastic element for force measurement, torque measurement. Strain gages-strain sensitivity of gage metals,gage construction,gage sensitivity and gage factor, performance characteristics, environmental effects,Strain gage circuits, Potentiometer, Wheat Stone's bridges, Constant current circuits. Strain analysis mmethods-two element and three element, rectangular and delta rosettes, correction for transverse strains effects, stress gage- plane shear gage, stress intensity factor gage.

Module-3

Stress Analysis: Two Dimensional Photo elasticity-natureoflight,-wavetheoryoflight,-opticalinterference-Polariscopesstressopticlaw effect of stressed model in plane and circular polariscopes, Isoclinics, Isochromatics fringe order determination-Fringe multiplication techniques-Calibration photo elastic model materials. Separation methods shear difference method, Analytical separation methods, Model to prototype scaling.

Module-4

Three Dimensional Photo elasticity: Stress freezing method, General slice, Effective stresses, Stresses separation, Shear deference method, Oblique incidence method, secondary principal stresses,scattered light photo elasticity,Polariscope and stress data analyses**.**

Module-5

Coating Methods: a) Photo elastic Coating Method-Birefringence coating techniques, Sensitivity Reinforcing and thickness effects -data reduction-Stress separation techniques, Photo elastic strain gauges.

b) Brittle Coatings Method: Brittle coating technique Principles data analysis-coating materials, Coating techniques.

c) Moire Technique-Geometrical approach, Displacement approach-sensitivity of Moire data reduction, Inplane and outplane Moire methods, Moire photography, Moire grid production.

Holography: Introduction, Equation for plane waves and spherical waves, Intensity, Coherence, Spherical radiator as an object (record process), Hurter, Driffeld curves, Reconstruction process, Holographic inter - feromerty, Real time and double exposure methods, Displacement measurement, Isopachics.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/ Textbooks

1. Holman, "Experimental Methods for Engineers" 7th Edition, Tata McGraw-Hill Companies, nc, New York, 2007.

2. R.S.Sirohi, H.C.Radha Krishna," Mechanical measurements" New Age International Pvt. Ltd., New Delhi, 2004

3. Experimental Stress Analysis - Srinath, Lingaiah, Raghavan, Gargesa, Ramachan draand Pant, Tata Mc Graw Hill, 1984.

Instrumentation, Measurement and Analysis - Nakra & Chaudhry, BC Nakra K Chaudhry,TataMcGraw

Reference Books
1. Measurement Systems Application and Design-Doeblin E.A., 4th (S.I.) Edition, McGraw Hill, New York, 1989 2. Design and Analysis of Experiments – Montgomery D.C., John Wiley & Sons, 1997. 3. Experimental Stress Analysis – Dally and Riley, McGraw Hill, 1991. 4. Experimental Stress Analysis-Sadhu Singh, Khanna publisher, 1990. 5. Photo elasticity VolI and VolII - M.M.Frocht., John Wileyandsons, 1969.

(Group-6): **Course Code : 20MST31**

Course Title : PLASTIC PROCESSING

Exam Hours: 3 hours	**Exam Marks (Maximum):100**

Module-1

Plastic Processing: Basic principle of processing, shape and size, processing parameters, their effect and behaviour, Rheology of ideal fluids, and real polymers, Effects of melt behaviour on processing and product performance. Injection Moulding: Principles, process variables, moulding cycle, machinery used, parts and function, specification, construction and maintenance of injection moulding machine, start up and shut down procedure, cylinder, nozzles, interaction of moulding variables, press capacity, projected area, shot weight, concepts and their relationship to processing, trouble shooting in injection moulding, microprocessors controlled injection moulding machines.

Module-2

Extrusion: Basic principles of extruders, and extrusion process, different types of extrudes i.e. barrel, screw, drive mechanics, head, constructional features of dies, sizing and haul-off equipment for extruders of mono filaments and tubes, blown film lines, wire and cable covering system, pipe profile extrusion, co-extrusion, process variables in extrusion like heating, temperature control, dies well, and melt fracture, spacing and orientation, treating, printing and sealing, quality of extruder products, fault, causes and remedy. Compression and Transfer Moulding: Techniques, various types of compression moulds, machinery used, and common moulding faults and remedies. Transfer moulding, its advantage over compression moulding, equipment used, press capacity, integral mold, and auxiliary mould, moulding cycle, ram pressure, clamping pressure, faults and remedies.

Module-3

Blow Moulding: Blow moulding process, processing parameter, materials used, hand operated and automatic blow moulding machine, extrusion blow moulding, moulding cycle, faults and remedies. Thermo Forming: Basic principles, types of thermoforming, thermoforming moulds, processing parameters, faults and remedies. Rotational Moulding: Basic principle, charge size, wall thickness, temperature control, fault causes and remedies.

Module-4

Calendaring: Basic principle, process variable, end product properties and applications, secondary processing techniques like powder coating, casting, machining, and joining of plastics, metalizing, printing.

Module-5

Processing of Engineering Plastics: precautions, and start up procedure, preheating, shutdown procedure, quality control, and waste management. Ram Extrusion of PTFE, Processing of reinforced plastics, like filament winding, Hand-lay-up, spray moulding, SMC, DMC, Centrifugal casting, Pultrusion, resin transfer moulding.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook/ Textbooks

Handbook of Plastic Processes Editor(s): Charles A. Harper First published: 7 October 2005 Print ISBN: 9780471662556 |Online ISBN: 9780471786580 |DOI:10.1002/0471786586 Copyright © 2006 John Wiley & Sons, Inc.

Plastics processing technology Front Cover Edward A. Muccio ASM International, 1994 - Technology & Engineering - 320 pages

Plastic Processing Data Hand Book – Dominic V Rosat o P.E.

Modern Plastics Hand Book – Charles A Harper.

Reference Books

1. Injection Mould Design, Pye R.G. W. - New York-John Wiley & Sons 12th Ed.1989.
2. Injection Moulding Theory & Practice, Rubin. J. Irvin, New York John Wiley & Sons.
3. Blow Moulding Hand Book, Rosato, New York-Oxford University-Hanser Publishers.
4. Principles of Rotational Moulding Process, Bruins.