DR. A. P. J. ABDUL KALAM TECHNICAL UNIVERSITY

LUCKNOW, UTTAR PRADESH

STUDY & EVALUATION SCHEME WITH SYLLABUS

FOR

B. TECH. 3rd YEAR

MECHANICAL ENGINEERING

[Effective from Session: 2020-21]

Syllabus Content of B. Tech Mechanical Engineering

S. No.	Code	Departmental Component	Subject Name	L T P	Credits	Page No.
1	**Third Year Evaluation Scheme (V & VI Semester)**					03
2	**Departmental Electives from Fifth to Seventh Semester &Suggested MOOCs Courses**					04
3	KME 501	Core	Heat and Mass Transfer	3 1 0	4	06
4	KME 502	Core	Strength of Material	3 1 0	4	08
5	KME 503	Core	Industrial Engineering	3 1 0	4	10
6	KME 551	Lab	Heat and Mass Transfer Lab	0 0 2	1	12
7	KME 552	Lab	Python Lab	0 0 2	1	13
8	KME 553	Lab	Internet of Things Lab	0 0 2	1	15
9	KME 051	Elective I	Computer Integrated Manufacturing	3 0 0	3	17
10	KME 052	Elective I	Mechatronics Systems	3 0 0	3	19
11	KME 053	Elective I	Finite Element Methods	3 0 0	3	21
12	KME 054	Elective I	I C Engine Fuel and Lubrication	3 0 0	3	22
13	KAU 051	Elective I	Automobile Engines & Combustion	3 0 0	3	24
14	KME 055	Elective II	Advance welding	3 0 0	3	26
15	KME 056	Elective II	Programming, Data Structures and Algorithms Using Python	3 0 0	3	28
16	KME 057	Elective II	Mechanical Vibrations	3 0 0	3	29
17	KME 058	Elective II	Fuels and Combustion	3 0 0	3	31
18	KAU 052	Elective II	Automotive chassis and suspension	3 0 0	3	33
19	KME 601	Core	Refrigeration and Air Conditioning	3 1 0	4	35
20	KME 602	Core	Machine Design	3 1 0	4	37
21	KME 603	Core	Theory of Machines	3 1 0	4	39
22	KME 651	Lab	Refrigeration and Air Conditioning Lab	0 0 2	1	41
23	KME 652	Lab	Machine Design Lab	0 0 2	1	42
24	KME 653	Lab	Theory of Machines Lab	0 0 2	1	43
25	KME 061	Elective III	Nondestructive Testing	3 0 0	3	44
26	KME 062	Elective III	Artificial Intelligence	3 0 0	3	46
27	KME 063	Elective III	Tribology	3 0 0	3	48
28	KME 064	Elective III	Gas Dynamics and Jet Propulsion	3 0 0	3	50
29	KAU 061	Elective III	Automotive Electrical and Electronics	3 0 0	3	51
30	**Fourth Year Evaluation Scheme (VII & VIII Semester) Effective in session 2021-22**					53
31	KME 071	Elective IV	Additive Manufacturing	3 0 0	3	54
32	KME 072	Elective IV	HVAC systems	3 0 0	3	56
33	KAU 072	Elective IV	Hybrid Vehicle Propulsion	3 0 0	3	58
34	KME 073	Elective V	Mathematical Modeling of Manufacturing Processes	3 0 0	3	60
35	KME 074	Elective V	Machine Learning	3 0 0	3	62
36	KME 075	Elective V	Computer Graphics and product modeling	3 0 0	3	64
37	KME 076	Elective V	Power Plant Engineering	3 0 0	3	66
38	KAU 073	Elective V	Vehicle Body Engineering & safety	3 0 0	3	68

B. Tech Mechanical Engineering
Evaluation Scheme

SEMESTER- V													
Sl. No.	Code	Subject	Periods			Evaluation Scheme				End Semester		Total	Credits
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KME 501	Heat and Mass Transfer	3	1	0	30	20	50		100		150	4
2	KME 502	Strength of Material	3	1	0	30	20	50		100		150	4
3	KME 503	Industrial Engineering	3	1	0	30	20	50		100		150	4
4		Departmental Elective-I	3	0	0	30	20	50		100		150	3
5		Departmental Elective-II	3	0	0	30	20	50		100		150	3
6	KME 551	Heat Transfer LAB	0	0	2				25		25	50	1
7	KME 552	Python Lab	0	0	2				25		25	50	1
8	KME 553	Internet of Things Lab	0	0	2				25		25	50	1
9	KME 554	Mini Project or Internship Assessment*	0	0	2				50			50	1
10	KNC501/ KNC502	Constitution of India, Law and Engineering / Indian Tradition, Culture and Society	2	0	0	15	10	25		50			NC
11	MOOCs (Essential for Hons. Degree)												
		Total	**17**	**3**	**6**							**950**	**22**

***The Mini Project or internship (4 - 5 weeks) conducted during summer break after IV semester and will be assessed during V semester.

SEMESTER- VI													
Sl. No.	Code	Subject	Periods			Evaluation Scheme				End Semester		Total	Credits
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KME 601	Refrigeration and Air Conditioning	3	1	0	30	20	50		100		150	4
2	KME 602	Machine Design	3	1	0	30	20	50		100		150	4
3	KME 603	Theory of Machine	3	1	0	30	20	50		100		150	4
4		Departmental Elective-III	3	0	0	30	20	50		100		150	3
5		Open Elective-I	3	0	0	30	20	50		100		150	3
6	KME 651	Refrigeration and Air Conditioning Lab	0	0	2				25		25	50	1
7	KME 652	Machine Design Lab	0	0	2				25		25	50	1
8	KME 653	Theory of Machine Lab	0	0	2				25		25	50	1
9	KNC601/ KNC602	Constitution of India, Law and Engineering / Indian Tradition, Culture and Society	2	0	0	15	10	25		50			NC
10		**Total**	**17**	**3**	**6**							**900**	**21**

It is suggested that the students should choose Departmental Electives Specializationwise that will support them to gain enough learning of the chosen Specialization.

Department Electives

	Specialization-1	**Specialization-2**	**Specialization-3**	**Specialization-4**	**Specialization-5**
Specialization	**Manufacturing and Automation**	**Automation and Industry 4.0**	**Design and Analysis**	**Thermal Engineering**	**Automobile Engineering**
Sem V Code	KME 051	KME 052	KME 053	KME 054	KAU 051
Departmental Elective-I	Computer Integrated Manufacturing	Mechatronics Systems	Finite Element Methods	I C Engine Fuel and Lubrication	Automobile Engines & Combustion
Sem V Code	KME 055	KME 056	KME 057	KME 058	KAU 052
Departmental Elective-II	Advance welding	Programming, Data Structures And Algorithms Using Python	Mechanical Vibrations	Fuels and Combustion	Automotive chassis and suspension
Sem VI Code	KME 061	KME 062	KME 063	KME 064	KAU 061
Departmental Elective-III	Non destructive Testing	Artificial Intelligence	Tribology	Gas Dynamics and Jet Propulsion	Automotive Electrical and Electronics
Sem VII Code	KME 071			KME 072	KAU 072
Departmental Elective-IV	Additive manufacturing (Common to all Three Specializations)			HVAC systems	Hybrid Vehicle Propulsion
Sem VII Code	KME 073	KME 074	KME 075	KME 076	KAU 073
Departmental Elective-V	Mathematical Modeling of Manufacturing Processes	Machine Learning	Computer Graphics and product modeling	Power Plant Engineering	Vehicle Body Engineering & safety

It is suggested that the students may also do the following MOOCs in addition to mandatory courses. This will enhance their learning in a particular Specialization. One MOOC per semester is recommended.

Suggested MOOCs Course

Specialization	Specialization -1	Specialization -2	Specialization -3	Specialization -4	Specialization -5
	Manufacturing and Automation	**Automation and Industry 4.0**	**Design and Analysis**	**Thermal Engineering**	**Automobile Engineering**
Sem V	**Advance Machining Process** https://swayam.gov.in/nd1_noc20_me76/preview By Prof.Manas Das, IIT Guwahati	**Control Systems** https://swayam.gov.in/nd1_noc20_ee90/preview By Prof. C. S. Shankar Ram, IIT Madras	**Experimental Stress Analysis** https://swayam.gov.in/nd1_noc20_me02/preview By Prof. K. Ramesh IIT Madras	**Fluid dynamics and turbo machines** https://swayam.gov.in/nd1_noc20_me75/preview By Prof.Dhiman Chatterjee, Prof.Shamit Bakshi, IIT Madras	**Vehicle Dynamics** https://nptel.ac.in/courses/107/106/107106080/ Prof P R Krishnakumar, IIT Madras
Sem VI	**Introduction to robotics**https://swayam.gov.in/nd1_noc20_de11/preview By Prof. Asokan T, Prof. Balaraman Ravindran, Prof. Krishna Vasudevan, IIT Madras	**Introduction to robotics** https://swayam.gov.in/nd1_noc20_de11/preview By Prof. Asokan T, Prof. Balaraman Ravindran, Prof. Krishna Vasudevan, IIT Madras	**Introduction to CFD** https://swayam.gov.in/nd1_noc20_ae11/preview By Prof. Arnab Roy, IIT Kharagpur	**Introduction to CFD** https://swayam.gov.in/nd1_noc20_ae11/preview By Prof. Arnab Roy, IIT Kharagpur	**Control Systems**https://swayam.gov.in/nd1_noc20_ee90/preview By Prof. C. S. Shankar Ram, IIT Madras
Sem VII	**Automation in Manufacturing** https://swayam.gov.in/nd1_noc20_me58/preview By Prof. Shrikrishna N. Joshi, IIT Guwahati	**Introduction to Industry 4.0 and Industrial Internet of Things** https://swayam.gov.in/nd1_noc20_cs69/preview By Prof. Sudip Misra, IIT Kharagpur	**Introduction to Composites** https://swayam.gov.in/nd1_noc20_me95/preview By Prof.Nachiketa Tiwari, IIT Kanpur	**Fundamentals of Compressible Flow** https://swayam.gov.in/explorer?searchText=Compressible%20Flow By Prof. Niranjan Sahoo, IIT Guwahati	**Introduction to hybrid and Electric Vehicles** MOOC: https://nptel.ac.in/courses/108/103/108103009/ Dr. Praveen Kumar, Prof. S. Majhi, IIT Guwahati
Sem VIII	**Production and Operation Management** https://swayam.gov.in/nd1_noc20_mg06/preview By Prof. Rajat Agrawal, IIT Roorkee	**Supply Chain management** https://swayam.gov.in/nd2_cec20_mg11/preview By Dr. P. Chitramani, Avinashilingam Institute for Home Science and Higher Education for Women	**Material Characterization**https://swayam.gov.in/nd1_noc20_mm14/preview By Prof. Sankaran. S, IIT Madras	**Computational Fluid Dynamics for Incompressible Flows** https://swayam.gov.in/nd1_noc20_me06/preview By Prof.Amaresh Dalal, IIT Guwahati	**Fuel Cell Technology** https://nptel.ac.in/courses/103/102/103102015/ By Dr. Anil Verma, IIT Guwahati & Prof. S. Basu, IIT Delhi

Subject Code: KME 501	Heat and Mass Transfer	L T P : 3 1 0	Credits: 4

The students will be able to		Blooms Taxonomy
CO-1	Understand the fundamentals of heat and mass transfer.	K2
CO-2	Apply the concept of steady and transient heat conduction.	K3
CO-3	Apply the concept of thermal behavior of fins.	K3
CO-4	Apply the concept of forced and free convection.	K3
CO-5	Apply the concept of radiation for black and non-black bodies.	K3
CO-6	Conduct thermal analysis of heat exchangers.	K4

UNIT-1

Introduction to Heat Transfer (L-5 Hours)

Introduction of thermodynamics and Heat Transfer, Modes of Heat Transfer: Conduction, convection and radiation, Effect of temperature on thermal conductivity of different types of materials, Introduction to combined heat transfer mechanism, General differential heat conduction equation in the rectangular, cylindrical and spherical coordinate systems, Initial and system boundary conditions.

Steady State one-dimensional Heat conduction (L-3 Hours)

Simple and Composite Systems in rectangular, cylindrical and spherical coordinates with and without energy generation, Concept of thermal resistance, Analogy between heat and electricity flow, Thermal contact resistance and over-all heat transfer coefficient, Critical radius of insulation for cylindrical, and spherical bodies.

UNIT-2

Fins (L-3 Hours)

Heat transfer through extended surfaces and its classification, Fins of uniform cross-sectional area, Error in measurement of temperature of thermometer wells.

Transient Conduction (L-3 Hours)

Transient heat conduction, Lumped capacitance method, Time constant, Unsteady state heat conduction in one dimension only, Heisler charts and their applications.

UNIT-3

Forced Convection (L-5 Hours)

Basic concepts: Hydrodynamic boundary layer, Thermal boundary layer, Approximate integral boundary layer analysis, Analogy between momentum and heat transfer in turbulent flow over a flat surface, Mixed boundary layer, Flow over a flat plate, Flow across a single cylinder and a sphere, Flow inside ducts, Thermal entrance region, Empirical heat transfer relations, Relation between fluid friction and heat transfer, Liquid metal heat transfer.

Natural Convection (L-5 Hours)

Physical mechanism of natural convection, Buoyant force, Empirical heat transfer relations for natural

convection over vertical planes and cylinders, horizontal plates, cylinders and sphere, combined free and forced convection, Effect of turbulence.

UNIT-4

Thermal Radiation (L-8 Hours)

Basic concepts of radiation, Radiation properties of surfaces, Black body radiation Planck's law, Wein's displacement law, Stefan-Boltzmann law, Kirchhoff's law, Gray body, Shape factor, Black-body radiation, Radiation exchange between diffuse non-black bodies in an enclosure, Radiation shields, Radiation combined with conduction and convection; Absorption and emission in gaseous medium; Solar radiation; Greenhouse effect, Radiation network analysis.

UNIT-5

Heat Exchanger (L-5 Hours)

Different types of heat exchangers, Fouling factors, Overall heat transfer coefficient, Logarithmic mean temperature difference (LMTD) method, Effectiveness-number of transfer unit (NTU) method and Compact Heat Exchangers.

Condensation and Boiling (L-3 Hours)

Introduction of condensation phenomena, Heat transfer relations for laminar film condensation on vertical surfaces and on outside& inside of a horizontal tube, Effect of non-condensable gases, Drop wise condensation, Heat pipes, Boiling modes, pool boiling, Hysteresis in boiling curve, Forced convection boiling.

Introduction to Mass Transfer (L-2 Hours)

Introduction of Fick's law of diffusion, Steady state equimolar counter diffusion, Steady state diffusion through a stagnant gas film, Heat and Mass Transfer Analogy -Convective Mass Transfer Correlations

Reference Books:-

1. Fundamentals of Heat and Mass Transfer, by Incroperra& DeWitt, John Wiley and Sons
2. Heat and Mass Transfer by Cengel, McGraw-Hill
3. Heat Transfer by J.P. Holman, McGraw-Hill
4. Heat and Mass Transfer by Rudramoorthy and Mayilsamy, Pearson Education
5. Heat Transfer by Ghoshdastidar, Oxford University Press
6. A text book on Heat Transfer, by Sukhatme, University Press.
7. Heat Transfer by Venkateshan, Ane Books Pvt Ltd
8. Schaum's outline of Heat Transfer by Pitts & Sisson McGraw-Hill
9. Heat and Mass Transfer by R Yadav, Central Publishing House

Subject Code: KME 502	Strength of Material	L T P : 3 1 0	Credits: 4

Course Outcomes: The student will be able to		Blooms Taxonomy
CO 1	Understand the concept of stress and strain under different conditions of loading	K2
CO 2	Determine the principal stresses and strains in structural members	K3
CO 3	Determine the stresses and strains in the members subjected to axial, bending and torsional loads	K3
CO 4	Apply the concepts of stresses and strain in solving problems related to springs, column and pressure vessels	K3
CO 5	Calculate the slope, deflection and buckling of loaded members	K3
CO 6	Analyze the stresses developed in straight and curved beams of different cross sections	K4

Unit I **8 Hours**

Compound stress and strains: Introduction, normal stress and strain, shear stress and strain, stresses on inclines sections, strain energy, impact loads and stresses, state of plane stress, principal stress and strain, maximum shear stress, Mohr's circle for plane stress, three dimensional states of stress & strain, equilibrium equations, generalized Hook's law, theories of failure. Thermal Stresses.

Unit II **8 Hours**

Stresses in Beams: Pure Bending**,** normal stresses in beams, shear stresses in beams due to transverse and axial loads, composite beams.

Deflection of Beams: Differential equation of the elastic curve, cantilever and simply supported beams, Macaulay's method, area moment method, fixed and continuous beams

Torsion: Torsion, combined bending & torsion of solid & hollow shafts, torsion of thin walled tubes.

Unit III **8 Hours**

Helical and Leaf Springs: Deflection of springs by energy method, helical springs under axial load and under axial twist (respectively for circular and square cross sections) axial load and twisting moment acting simultaneously both for open and closed coiled springs, laminated springs.

Columns and Struts: Buckling and stability, slenderness ratio, combined bending and direct stress, middle third and middle quarter rules, struts with different end conditions, Euler's theory for pin ended columns, effect of end conditions on column buckling, Ranking Gordon formulae, examples of columns in mechanical equipment and machines.

Unit IV **8 Hours**

Thin cylinders & spheres: Introduction, difference between thin walled and thick walled pressure vessels, thin walled spheres and cylinders, hoop and axial stresses and strain, volumetric strain.

Thick cylinders: Radial, axial and circumferential stresses in thick cylinders subjected to internal or external pressures, compound cylinders, stresses in rotating shaft and cylinders, stresses due to interference fits.

Unit V **8 Hours**

Curved Beams: Bending of beams with large initial curvature, position of neutral axis for rectangular, trapezoidal and circular cross sections, stress in crane hooks, stress in circular rings subjected to tension or compression.

Unsymmetrical Bending: Properties of beam cross-section, slope of neutral axis, stress and deflection in unsymmetrical bending, determination of shear center and flexural axis (for symmetry about both axis and about one axis) for I-section and channel section.

Text Books:

1. Strength of materials by Sadhu Singh, Khanna Book Publishing Co. (P) Ltd.
2. Strength of Material by Rattan, MC GRAW HILL INDIA
3. Mechanics of Materials by B.C. Punmia, Laxmi Publications (P) Ltd.

Reference Books:

1. Mechanics of Materials by Hibbeler, Pearson.
2. Mechanics of material by Gere, Cengage Learning
3. Mechanics of Materials by Beer, Jhonston, DEwolf and Mazurek, MC GRAW HILL INDIA
4. Strength of Materials by Pytel and Singer, Harper Collins
5. Strength of Materials by Ryder, Macmillan.
6. Strength of Materials by Timoshenko and Yσungs, East West Press.
7. Introduction to Solid Mechanics by Shames, Pearson
8. Mechanics of material by Pytel, Cengage Learning
9. An Introduction to Mechanics of Solids by Crandall, MC GRAW HILL INDIA
10. Strength of Materials by Jindal, Pearson Education
11. Strength of Materials by Basavajaiah and Mahadevappa, University Press.

Subject Code: KME 503	Industrial Engineering	L T P : 3 1 0	Credits: 4

Course Outcomes: The students will be able to		Blooms Taxonomy
CO1	Understand the concept of production system, productivity, facility and process planning in various industries	K2
CO2	Apply the various forecasting and project management techniques	K3
CO3	Apply the concept of break-even analysis, inventory control and resource utilization using queuing theory	K3
CO4	Apply principles of work study and ergonomics for design of work systems	K3
CO5	Formulate mathematical models for optimal solution of industrial problems using linear programming approach	K4

Unit-I:

Overview of Industrial Engineering: Types of production systems, concept of productivity, productivity measurement in manufacturing and service organizations, operations strategies, liability and process design.

Facility location and layout: Factors affecting facility location; principle of plant layout design, types of plant layout; computer aided layout design techniques; assembly line balancing; materials handling principles, types of material handling systems, methods of process planning, steps in process selection, production equipment and tooling selection, group technology, and flexible manufacturing.

Unit II:

Production Planning and control: Forecasting techniques – causal and time series models, moving average, exponential smoothing, trend and seasonality; aggregate production planning; master production scheduling; materials requirement planning (MRP) and MRP-II; routing, scheduling and priority dispatching, concept of JIT manufacturing system

Project Management: Project network analysis, CPM, PERT and Project crashing.

Unit III:

Engineering economy and Inventory control: Methods of depreciation; break-even analysis, techniques for evaluation of capital investments, financial statements, time-cost trade-off, resource levelling; Inventory functions, costs, classifications, deterministic inventory models, perpetual and periodic inventory control systems, ABC analysis, and VED analysis.

Queuing Theory: Basis of Queuing theory, elements of queuing theory, Operating characteristics of a queuing system, Classification of Queuing models.

Unit IV

Work System Design: Taylor's scientific management, Gilbreths's contributions; work study: method study, micro-motion study, principles of motion economy; work measurement –time study, work

sampling, standard data, Predetermined motion time system (PMTS); ergonomics; job evaluation, merit rating, incentive schemes, and wage administration.

Product Design and Development: Principles of product design, tolerance design; quality and cost considerations; product life cycle; standardization, simplification, diversification, value engineering and analysis, and concurrent engineering.

Unit V:

Operational Analysis: Formulation of LPP, Graphical solution of LPP, Simplex Method, Sensitivity Analysis, degeneracy and unbound solutions.transportation and assignment models; Optimality test: the stepping stone method and MODI method, simulation.

Books and References:

1. Industrial Engineering and Production Management by Martand T Telsang S. Chand Publishing
2. Industrial Engineering and Production Management by M. MahajanDhanpatRai& Co. (P) Limited
3. Industrial Engineering and Management by Ravi Shankar, Galgotia Publications Pvt Ltd
4. Production and Operations Management by Adam, B.E. & Ebert, R.J., PHI
5. Product Design and Manufacturing by Chitale A.V. and Gupta R.C., PHI
6. Operations Research Theory & Applications by J K Sharma, Macmillan India Ltd,
7. Production Systems Analysis and Control by J.L.Riggs, John Wiley & Sons
8. Automation, Production Systems & Computer Integrated Manufacturing by Groover, M.P. PHI
9. Operations Research, by A.M. Natarajan, P. Balasubramani, A. Tamilarasi, Pearson Education
10. Operations Research by P. K. Gupta and D. S. Hira, S. Chand & Co.

Subject Code: KME 551	Heat and Mass Transfer Lab	L T P : 0 0 2	Credits: 1

The students will be able to		Blooms Taxonomy
CO1	Apply the concept of conductive heat transfer.	K3
CO2	Apply empirical correlations for both forced and free convection to determine the value of convection heat transfer coefficient	K3
CO3	Apply the concept of radiation heat transfer for black and grey body.	K3
CO4	Analyze the thermal behaviour of parallel or counter flow heat exchangers	K4
CO5	Conduct thermal analysis of a heat pipe	K4

List of Experiments

Minimum eight experiment of the following

1. To determine thermal conductivity of conductive material(s).
2. To determine thermal conductivity of insulating material(s).
3. To determine heat conduction through lagged pipe.
4. To determine heat transfer through fin under natural convection.
5. To determine the heat transfer Rate and Temperature Distribution for a Pin Fin.
6. Determination of thermal conductivity of different types of fluids.
7. Experiment on Stefan's Law - determination of emissivity, etc.
8. Experiment on convective heat transfer through flat plate solar collector.
9. To compare LMTD and Effectiveness of Parallel and Counter Flow Heat Exchangers.
10. To find the heat transfer coefficient for Forced Convection in a tube.
11. To find the heat transfer coefficient for Free Convection in a tube.
12. To conduct experiments on heat pipe.
13. To study the rates of heat transfer for different materials and geometries.
14. Visit to a Thermal Power Station for practical exposure.

Subject Code: KME 552	Python Lab	L T P : 0 0 2	Credits: 1

Course outcomes: The students will be able to		Blooms Taxonomy
CO1	Apply conditional statement, loops condition and functions in python program	K3
CO2	Solve mathematical and mechanical problems using python program	K3
CO3	Plot various type of chart using python program	K3
CO4	Analyze the mechanical problem using python program	**K4**

List of Python Program

1. Write a program to find root of quadratic equation
2. Write a program to find and delete repeating number in Given List
3. Write a program to input and print the element sum of user defined matrix
4. Write a program to input and multiply two different matrices
5. Write a program to compute eigen value and vector of a given 3*3 matrix using NumPy
6. Write a program to find a solution of linear equations in y-mx+c
7. Write a program to draw line using equation y=mx+c
8. Write the program to determine the intersection point of two line.
9. Draw various types of charts using matplotlib
10. Write a program to perform equations of uniform motion of kinematics :

i. $v = u + at0$
ii. $s = ut + ½(at^2)$
iii. $v^2 = u^2 – 2as$

11. Write a menu driven program to perform following properties of thermodynamics as given below:

i. First Law of thermodynamics (U = Q - W), where ΔU is the change in the internal energy. Q is the heat added to the system, and W is the work done by the system.
ii. Efficiency of Heat Engine = TH – TC / TH where TH & TC is the temperature of HOT and COLD Reservoirs.

12. Write the menu program to find the to find the out relationship between stress and strain curve as given below:

i. Young's Modulus
ii. Shear Modulus
iii. Poisson Ratio

13. Write the program to determine the shear force and bending moment in beams.
14. Write a program to find maxima/minima of functions of two variables and evaluate some real definite and finite integrals.
15. Write a Program to find out unknown magnitude of TB and TD of unknown tension can be obtained from two scalar equations of equilibrium i.eEF_x = 0 and EF_y =0.
16. Write a program to perform interpolation of equally and unequally spaced data.
17. Write a program to calculate total pressure exerted in ideal fluid as equation is given below: $p+1/2(\rho v^2) + \rho gh$ =constant

Where P is Pressure, V is Velocity of fluid, ρ is density and h is the height of the container.

18. Write a program to find numerical differentiation using Finite differences Method by importing NumPy and plot the numerical values using matplotlib libraries of python.
19. Write a program for bresenham's line drawing algorithm.
20. Write a program for geometric transformation of a given object.

Subject Code: KME 553	Internet of Things Lab	L T P : 0 0 2	Credits: 1

Proposed By MIET

The students will be able to		Blooms Taxonomy
CO1	Understand Internet of Things and its hardware and software components	K2
CO2	Interface I/O devices, sensors & communication modules	K3
CO3	Remotely monitor data and control devices	K3
CO4	Design prototype of IoT based smart system	K4
CO5	Develop IoT based projects for real life problem	K6

List of Experiments:

S.No.	Name of Experiment	Outcome
1	Familiarization with concept of IoT, Arduino/Raspberry Pi and perform necessary software installation.	Will be able to understand IoT, Arduino/Raspberry Pi, and also able to install software setup of Arduino/ Respberry Pi
2	To interface motor using relay with Arduino/Raspberry Pi and write a program to turn ON/OFF motor.	Able to use relay to control motor and other mechanical devices
3	To interface sensors* with Arduino/Raspberry Pi and write a program to displaysensors data on the computer screen.	Able to retrieve data from sensors and to display it on computer screen
4	To interface OLED with Arduino/Raspberry Pi and write a program to display sensor data on it.	Able to retrieve data from sensors and to display it on OLED
5	To interface sensor with Arduino/Raspberry Pi and write a program to turn ON/OFF Relay when sensor data is detected.	Able to control relay with help of microcontroller and sensors
6	To interface sensor with Arduino/Raspberry Pi and write a program to turn ON/OFF Solenoid valve when sensor data is detected.	Able to control Solenoid valve with help of microcontroller and sensors
7	To interface sensor with Arduino/Raspberry Pi and write a program to turn ON/OFF Linear Actuator when sensor data is detected.	Able to control linear actuator with help of microcontroller and sensors
8	To interface sensor with Arduino/Raspberry Pi and write a program to turn ON/OFF Starter Motor when sensor data is detected.	Able to control Starter Motor with help of microcontroller and sensors
9	To interface Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to smart phone using Bluetooth.	Able to communicate sensor data from microcontroller to smart phone
10	To interface Bluetooth with Arduino/Raspberry Pi and write a program to turn Actuators* ON/OFF when message is received from smart phone using Bluetooth.	Able to control actuators using mobile phone through Bluetoth
11	Write a program on Arduino/Raspberry Pi to	Able to upload status of devices and

	upload Sensor data to thingspeak cloud.	sensors on web cloud
12	Write a program on Arduino/Raspberry Pi to retrieve sensors data from thingspeak cloud.	Able to retrieve status of devices and sensors from web cloud
13	Develop IoT based smart lock system for Motor cycle/Car	Able to develop smart lock system of motor cycle/car
14	Develop IoT based Smart water flow system	Able to develop smart water flow system
15.	Develop IoT based home security system	Able to develop smart home security system

Components required-

1. Arduino with cable
2. Raspberry Pi with cable and memory card
3. Node MCU
4. *Sensors-IR, LDR, DHT11 sensor, Push button, Pressure senser, Temperature sensor, Vibration, Rotation, Location, Torque, Sound, Weight etc.
5. *Actuators-LED, Buzzer, Relay Switch, Motors, Motor Drivers, OLED, Display, Linear Actuator, Solenoid Valve, Starter Motor etc.
6. Bluetooth Module, Wi-fi Module, Ethernet Module
7. Smart Phone
8. Computer
9. Power Supply-5V, 12V, 3.3V
10. Internet facility

Semester – V: Departmental Elective – I: Specialization – Manufacturing and Automation

Subject Code: KME 051	Computer Integrated Manufacturing	L T P : 3 0 0	Credits: 3

Course Outcome: Student will be able to		Bloom Taxonomy
CO 1	Understand the basic concepts of automation, computer numeric control machining	K2
CO 2	Understand the algorithms of line generation, circle generation, transformation, curve, surface modeling and solid modeling	K2
CO 3	Understand group technology, computer aided process planning, flexible manufacturing, Industry 4.0, robotics	K2
CO 4	Understand information system and material handling in CIM environment, rapid prototyping	K2
CO 5	Apply the algorithms of line & circle generation and geometric transformations	K3
CO6	Develop CNC program for simple operations	K3

Unit 1

Introduction to Computer Integrated Manufacturing (CIM): Introduction to CAD, CAM, CIM, Automated Manufacturing system; Need of automation, Basic elements of automation, Levels of automation, Automation Strategies, Advantages & disadvantages of automation, Historical development and future trends. Computer Integrated Manufacturing, Computers in manufacturing industries.

Unit 2

Principles of Computer Graphics:

Point plotting, drawing of lines, Bresenham's circle algorithm.

Transformation in Graphics:

2D transformations – rotation, scaling, translation, mirror, reflection, shear – homogeneous transformations – concatenation, 3D transformations.

Curves: Introduction to Hermite cubic splines, Bezier curves, B-spline curves, NURBS

Surface Modeling: Polygon surfaces, Quadric surfaces, Superquadric surfaces and blobby objects

Solid modeling: Boolean set operations, Primitive instancing, Sweep representation, Boundadry representation, Constructive solid geometry,

Unit 3

Computer Aided Manufacturing:

NC in CAM – Principal types of CNC machine tools and their construction
features – tooling for CNC – ISO designation for tooling – CNC operating system
Programming for CNC machining – coordinate systems – manual part programming – computer assisted part programming.

Unit 4

Group Technology: Group technology, Cellular Manufacturing, CAPP – Variant and Generative systems-

Concurrent Engineering and Design for Manufacturing.
Flexible Manufacturing System: characteristics – economics and technological justification – planning, installation, operation and evaluation issues – role of group technology and JIT in FMS – typical case studies future prospects, Industry 4.0.

Robotics: Classification and specification – drive and controls – sensors - end effectors - grippers- tool handling and work handling – machine vision – robot programming concepts – case studies in assembly. Introduction to Programmable logical controller

Unit 5
Data and information in CIM: Management information system in CIM environment, MRP – MRP II – ERP - Capacity planning.

Material handling in CIM environment: Types – AGVS – AS/RS – Swarf handling and disposal of wastes – single and mixed mode assembly lines – quantitative analysis of assembly systems.

Rapid prototyping: Need for rapid prototyping, Basic principles and advantages of RP, General features and classifications of different RP techniques with examples.

Books and References:
1. MikellP.Groover - Automation , Production Systems and Computer IntegratedManufacturing, Second edition, Prentice Hall of India.
2. Ibrahim Zeid - CAD/CAM theory and Practice, Tata McGraw Hill Publishing Co. Ltd.,Company Ltd., New Delhi.
3. YoramKoren,Control of machine tools,McGraw-Hill.
4. Hearn & Baker, Computer Graphics, Prentice Hall of India
5. Sunil Kumar Srivastava, Computer Aided Design: A Basic and Mathematical Approach, I K International Publishing House
6. P.Radhakrishnan, - CAD/CAM/CIM, New Age International (P) Ltd., New Delhi

Semester – V: Departmental Elective – I: Specialization – Automation and Industry 4.0

Subject Code: KME 052	Mechatronics Systems	L T P : 3 0 0	Credits: 3

Course Outcome: Student will be able to		Bloom Taxonomy
CO 1	Identify key elements of mechatronics and its representation by block diagram.	K 2
CO 2	Understand the concept of sensors and use of interfacing systems.	K 2
CO 3	Understand the concept and applications of different actuators	K 2
CO 4	Illustrate various applications of mechatronic systems.	K 2
CO 5	Develop PLC ladder programming and implementation in real life problem.	K 5

Unit I: Mechatronics & Its Scope

Mechatronics System: Introduction to Mechatronic Systems, Evolution, Scope, Application Areas, Basic Elements and Control of Mechatronics systems, Advantages and disadvantages of Mechatronics, Industrial applications of Mechatronics, autotronics, bionics, and avionics and their applications

Control System Concepts: Introduction to Control Systems, Elements of control system, Basic of open and closed loop control with example.

Unit II: Sensor & Transducer

Definition and classification of sensor and transducer, performance terminology, static and dynamic characteristics, Principle of working and application of Inductive Proximity, Capacitive Proximity, Photoelectric, Ultrasonic, Magnetic, Hall Effect, Tactile Sensor, load cell, LVDT and interfacing sensors in Mechatronic system.

UNIT III: ACTUATION SYSTEMS

Fluid Based Actuation: Concept of Hydraulic and Pneumatic Actuation system, Oil and Air preparation unit, Direction Control Valve, Pressure Control Valve, Single and doubly actuated systems, Actuators and Accumulators.

Electrical Actuation Systems: Introduction to Switching devices,Concept of Electro Mechanical Actuation, Solenoids and Solenoid Operated Direction Control Valves, Principle of working of DC and 3 Phase Induction Motor, Stepper motors and Servo Motors with their merits and demerits.

UNIT IV: INDUSTRIAL CONTROLLERS

Programmable Logic Controllers: Basic Structure, Types and Working Principle, Concept of Scan Cycle and Scan Time, IO's and its Types, Selection Criteria and Applications

Programming Techniques: Ladder diagram –Concept of Contacts and Coil, Latching/ Holding Circuit, Memory Bits, Timers and Counter.

UNIT V: MECHATRONICS APPLICATIONS:

Control of conveyor motor, sorting and packaging unit, pick and place robot, coin counter, operations of bottling plant, domestic washing machine, use of PLC for extending and retracting pneumatic pistons and their different combinations, automatic car park system, engine management system, other applications in manufacturing.

Text Books:

1. Rolf Isennann, " Mechatronics Systems", Springer, 2005.
2. W. Bolten, "Mechatronics", Pearson Education 2003.
3. HMT Ltd, "Mechatronics:, Tata McGraw Hill 1998.
4. K. P. Ramachandran, G.K. Vijayaraghavan, M.S. Balasundaram, Mechatronics - Integrated Mechanical Electronic Systems, Wiley.

Semester – V: Departmental Elective – I: Specialization – Design and Analysis

Subject Code: KME 053	Finite Element Methods	L T P : 3 0 0	Credits: 3

Course Outcome: Student will be able to		Bloom Taxonomy
CO 1	Understand the basic concepts of FEM and its applications.	K2
CO 2	Apply the procedure involved to solve a problem using Finite Element Methods.	K3
CO 3	Develop the element stiffness matrices using different approach.	K3
CO 4	Analyze 1D and 2D problem using different methods.	K4
CO 5	Analyze the complex geometric problems through FEM software packages.	K4

Unit 1

Introduction, exact solution vs approximate solution, principle of FEM, application of FEM, general procedure for finite element analysis, pre-processing, solution, post processing, Stresses and Equilibrium; Boundary Conditions.

Unit 2

Strain-Displacement Relations, Stress–strain relations, Effect of temperature, various approximate methods: weighted residual method, variational or Rayleigh Ritz method, Galerkin's method, principle of minimum potential energy.

Unit 3

Basic element shapes, generalized co-ordinates, polynomials, natural co-ordinates in one-, two- and three-dimensions, Lagrange and Hermite polynomials, Application of Finite Element Methods to elasticity problems and heat conduction Problems.

Unit 4

One dimensional problem of finite element model, Coordinates and Shape function, Potential-energy approach, Galerkine approach, Assembly of Global Stiffness Matrix and Load Vector.

Plane trusses: Global and local coordinate system and stress calculation.
Beams and Frames: finite element formulation and calculation of Shear Force and Bending Moment.

Unit 5

Two-dimensional problem using Constant Strain Triangles and Four-node Quadrilateral, Problem modelling and Boundary conditions.

Practical consideration in finite element applications, problem solving on a general purpose FEM software package like ANSYS, ABAQUS, NISA etc.

Text Books:

1. Chandrupatla, T. R. and Belegundu, A. K., Introduction to Finite Elements in Engineering, Pearson Education, India (2001).
2. Rao, S. S., Finite element method in engineering, 5th Edition, Pergaman Int. Library of Science, 2010.
3. Huebner, K. H., The Finite Element Method for Engineers, John Wiley, New York (2001).
4. Logan, D. L., A first course in the finite element method,6th Edition, Cengage Learning, 2016.

Semester – V: Departmental Elective – I: Specialization – Thermal Engineering

Subject Code: KME 054	I C Engine, Fuel and Lubrication	L T P : 3 0 0	Credits: 3

CO	Course Outcome	Bloom Taxonomy
CO 1	Explain the working principle, performance parameters and testing of IC Engine.	K 2
CO 2	Understand the combustion phenomena in SI and CI engines and factors influencing combustion chamber design.	K 2
CO 3	Understand the essential systems of IC engine and latest trends and developments in IC Engines.	K 2
CO 4	Understand the effect of engine emissions on environment and human health and methods of reducing it.	K 2
CO 5	Apply the concepts of thermodynamics to air standard cycle in IC Engines	K 3
CO 6	Analyze the effect of various operating parameters on IC engine performance.	K 4

Unit-I **(9 Hours)**

Introduction to I.C Engines: Engine classification and basic terminology, Two and four stroke engines, SI and CI engines, Valve timing diagram, Valve mechanism- Push rod type, Overhead type (SOHC,DOHC).
Thermodynamic analysis of Air standard cycles: Otto cycle, Diesel cycle, Dual cycle, Comparison of Otto, Diesel and Dual cycles Fuel air cycle, factors affecting the fuel air cycle, Actual cycle.
Testing and Performance: Performance parameters, Basic measurements, Blow by measurement, Testing of SI and CI engines.

Unit–II **(7 Hours)**

Combustion: Stages of Combustion in SI & CI engine, Factors affecting combustion, Flame speed, Ignition Delay, Abnormal combustion and its control.
Combustion chamber: Squish, Swirl & tumble, Combustion chamber design for SI & CI engine & factors affecting it.

Unit–III **(8 Hours)**

Carburetion, Mixture requirements, Carburetors and fuel injection system in SI Engine, MPFI, Scavenging in 2 Stroke engines.

Fuel injection in CI engines, Requirements, Types of injection systems, Fuel pumps, Fuel injectors, Injection timings.

Turbocharging & its types- Variable Geometry Turbocharger, Waste Gate Turbocharger, Effect of turbocharging on power & emission.

Unit-IV **(9 Hours)**

Engine Emission and Control: Pollutant - Sources and types – Effect on environment and human health - formation of NOx - Hydrocarbon Emission Mechanism - Carbon Monoxide Formation - Particulate emissions - Methods of controlling Emissions - Catalytic converters and Particulate Traps - Selective Catalytic Reduction(SCR) - Diesel Oxidation Catalyst (DOC).

Fuels: Fuels for SI and CI engine, Important qualities of SI and CI engine fuels, Rating of SI engine and CI engine fuels, Dopes, Additives, Gaseous fuels, LPG, CNG, Biogas, Producer gas, Alternative fuels for IC engines.

UNIT-V **(9 Hours)**

Engine Cooling and Lubrication: Different cooling systems, Radiators and cooling fans, Engine friction, Lubrication principle, Type of lubrication, Lubrication oils, Crankcase ventilation.

Ignition System in SI Engine: Ignition system requirements, Magneto and battery ignition systems, ignition timing and spark plug, Electronic ignition.

Recent trends in IC engine: Lean burn engine, Stratified charge spark ignition engine, Homogeneous charge spark ignition engine, GDI.

Text Books

1. A Course in International Combustion Engines, by Mathur& Sharma, DhanpatRai& Sons.
2. I.C Engine, by Ganeshan, Tata McGraw Hill Publishers.

Reference Books

1. I.C Engine Analysis & Practice by E.F Obert.
2. Internal Combustion Engine Fundamentals, by John B. Heywood, Tata Mcgraw Hill Publishers.
3. Engine Emission, by B. B. Pundir, Narosa Publication.
4. Engineering Fundamentals of Internal Combustion Engines by W.W. Pulkrabek, Pearson Education.
5. Fundamentals of Internal Combustion Engine by Gill, Smith, Ziurs, Oxford & IBH Publishing CO.
6. Fundamentals of Internal Combustion Engines by H.N. Gupta, Prentice Hall of India.

Semester – V: Departmental Elective – I: Specialization – Automobile Engineering

Subject Code: KAU 051	Automobile Engines & Combustion	L T P : 3 0 0	Credits: 3

Proposed By MIET

CO	Course Outcome	Bloom Taxonomy
CO 1	Explain the working principle, performance parameters and testing of IC Engine.	K 2
CO 2	Understand the phenomena of combustion and its application in SI and CI engines.	K 2
CO 3	Understand the essential systems of IC engine.	K 2
CO 4	Understand the effect of engine emissions on environment and human health and methods of reducing it.	K 2
CO 5	Apply the concepts of thermodynamics to air standard cycle in IC Engines	K 3
CO 6	Analyze the effect of various operating parameters on IC engine performance.	K 4

Unit-I (8 Hours)

Introduction to I.C Engines: Engine classification and basic terminology, Two and four stroke engines, SI and CI engines, Valve timing diagram, Valve mechanism- Push rod type, Overhead type (SOHC,DOHC).

Thermodynamic analysis of Air standard cycles: Otto cycle, Diesel cycle, Dual cycle, Comparison of Otto, Diesel and Dual cycles Fuel air cycle, factors affecting the fuel air cycle, Actual cycle.

Testing and Performance: Performance parameters, Basic measurements, Blow by measurement, Testing of SI and CI engines.

Unit–II (8 Hours)

Combustion and Flames Propagation:

Chemical composition– Flue gas analysis, Dew point of products, Stoichiometry, Stoichiometry relations, theoretical air required for complete combustion, Enthalpy of formation, Heating value of fuel, Adiabatic flame Temperature, Chemical equilibrium.

Flame stability, Burning velocity of fuels, Measurement of burning velocity, Factors affecting the burning velocity, Flame Propagation, Flame Temperature– Theoretical, Adiabatic & Actual, Ignition Limits, Limits of Inflammability.

Unit–III (7 Hours)

Combustion: Stages of Combustion in SI & CI engine, Factors affecting combustion, Flame speed, Ignition Delay, Abnormal combustion and its control.

Combustion chamber: Squish, Swirl & tumble, Combustion chamber design for SI & CI engine & factors affecting it.

Ignition System in SI Engine: Ignition system requirements, Magneto and battery ignition systems, ignition timing and spark plug, Electronic ignition.

Unit-IV **(9 Hours)**

Carburetion, Mixture requirements, Carburetors and fuel injection system in SI Engine, MPFI, Scavenging in 2 Stroke engines.

Fuel injection in CI engines, Requirements, Types of injection systems, Fuel pumps, Fuel injectors, Injection timings.

Turbocharging & its types- Variable Geometry Turbocharger, Waste Gate Turbocharger, Effect of turbocharging on power & emission.

UNIT-V **(8 Hours)**

Engine Emission and Control: Pollutant - Sources and types – Effect on environment and human health - formation of NOx - Hydrocarbon Emission Mechanism - Carbon Monoxide Formation - Particulate emissions - Methods of controlling Emissions - Catalytic converters and Particulate Traps - Selective Catalytic Reduction(SCR) - Diesel Oxidation Catalyst (DOC).

Fuels & Lubricants: Fuels for SI and CI engine, Rating of SI engine and CI engine fuels, Gaseous fuels, LPG, CNG, Biogas, Different cooling systems, Type of lubrication, Lubrication oils, Crankcase ventilation.

Text Books

3. A Course in International Combustion Engines, by Mathur& Sharma, DhanpatRai& Sons.
4. Fuels and combustion, Sharma and Chander Mohan, Tata McGraw Hill
5. I.C Engine, by Ganeshan, Tata McGraw Hill Publishers.

Reference Books

7. I.C Engine Analysis & Practice by E.F Obert.
8. Internal Combustion Engine Fundamentals, by John B. Heywood, Tata Mcgraw Hill Publishers.
9. Engine Emission, by B. B. Pundir, Narosa Publication.
10. Engineering Fundamentals of Internal Combustion Engines by W.W. Pulkrabek, Pearson Education.
11. Fundamentals of Internal Combustion Engine by Gill, Smith, Ziurs, Oxford & IBH Publishing CO.
12. Fundamentals of Internal Combustion Engines by H.N. Gupta, Prentice Hall of India.

Semester – V: Departmental Elective – II: Specialization – Manufacturing and Automation

Subject Code: KME 055	Advance welding	L T P : 3 0 0	Credits: 3

Course Outcome: Student will be able to		Bloom Taxonomy
CO 1	Understand the physics of arc welding process and various operating characteristics of welding power source.	K2
CO 2	Analyse various welding processes and their applications.	K3
CO 3	Apply the knowledge of welding for repair & maintenance, along with the weldability of different materials.	K3
CO 4	Apply the concept of quality control and testing of weldments in industrial environment.	K3
CO 5	Evaluate heat flow in welding and physical metallurgy of weldments.	K4

UNIT-I:

Introduction: Introduction to welding, application, classification and process selection criterion. Health & safety in welding.

Welding Arc: Physics of welding arc, arc initiation, voltage distribution, arc characteristics, arc efficiency, arc temperatures and arc blow.Mechanism and types of metal transfer.

Welding Power Sources: Types of welding power sources, operation characteristics and specifications.

UNIT-II:

Welding Processes: Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW) Gas Tungsten Arc Welding (GTAW) Plasma Arc, Submerged Arc Welding, Electro gas and Electroslag, Resistance welding, Friction welding, Brazing, Soldering & Braze welding. Laser beam welding, Electron beam welding, Ultrasonic welding, Explosive welding, Friction Stir Welding, Underwater welding.

Advances in Welding Processes: Narrow Gap, Tandem (Twin / Multi Wire) Welding, A-TIG, Hybrid Welding processes**,** Magnetically impelled arc butt (MIAB) welding**,** welding automation and robotic applications.

UNIT-III:

Heat Flow Welding: Weld thermal cycle, Temperature distribution, Peak temperature; Heat Affected Zone (HAZ), heating, cooling and solidification rates.

Welding Metallurgy: Fundamentals of physical metallurgy, Principle of solidification of weld metal, Reactions in weld pool - Gas metal reaction, Slag metal reaction, factors affecting changes in microstructure and mechanical properties of HAZ, Micro and macro structures in weld metal and HAZ

UNIT-IV:

Repair & Maintenance Welding: Hardfacing, Cladding, Surfacing, Metallizing processes and Reclamation welding.

Weldability: Effects of alloying elements on weldability, carbon equivalent, welding of plain carbon steel, Stainless steel, Cast Iron and Aluminium alloys, Welding of Dissimilar Materials

UNIT-V:

Weld Design: Types of welds & joints, Welding Symbols, Weld defects and Remedies, Residual Stresses & Distortion, Inspection and testing of welds: Introduction to Non Destructive Techniques; Destructive Techniques - Bulk and Microhardness test, Wear test and types, corrosion test, tensile test, bend test, SEM, EDS and XRD.

Welding Codes, WPS & PQR: Introduction to welding codes, ISO, ASME and BIS specifications, Welding Procedure Specification (WPS) & Procedure Qualification Record (PQR), Welding of pipe-lines and pressure vessels.

Books and References:

1. Welding and Welding Technology, by- Richard L. Little, McGraw Hill Education.
2. Welding Principals and Practices, by- Edwars R. Bohnart, McGraw Hill Education.
3. Welding Engineering and Technology, by- R. S. Parmar, KhannaPublishsers.
4. Welding Technology Fundamentals by William. A. Bowditch.
5. Welding Technology by N K Srinivasan.
6. Welding Engineering and Technology by R S Parmar.
7. Modern Welding Technology by Howard B Cary and Scott Helzer.
8. Welding Handbooks (Vol. I & II)
9. Advanced Welding Processes, Woodhead publishing, J. Norrish
10. ASME Sec. IX, Boiler and Pressure Vessel Code

Semester – V: Departmental Elective – II: Specialization – Automation and Industry 4.0

Subject Code: KME 056	Programming, Data Structures And Algorithms Using Python	L T P : 3 0 0	Credits: 3

Course Outcome: Student will be able to		Bloom Taxonomy
CO 1	Understand the numbers, math's function, strings, list, tuples, and dictionaries in pythons	K2
CO 2	Apply conditional statement and functions in python	K3
CO 3	Apply file handling techniques in python	K3
CO 4	Analyze the graphical demonstration in python	K4
CO 5	Apply techniques of Classes and Object Concept in Python	K3

UNIT 1: Introduction (8 Hours)

Introduction to Python, Python IDE's, Assignment statement, basic types - int, float, complex, bool, Strings, Lists, bytes, byte array, Functions, Loop control statements-break, continue, pass, Anonymous function-filter(),map(),reduce(), more about range().

UNIT 2: Data Structure (7Hours)

Arrays vs lists, Tuples and dictionaries, Sets, frozenset, Slicing,binary search, Efficiency, Selection Sort, Insertion Sort, Recursion, Mergesort, Quicksort.

UNIT 3: Function and File Handling (8 Hours)

Function definitions, Global scope, nested functions, Lambda Function, List Comprehension, Exception Handling, Standard input and output, Handling files, String functions, pass, del() and None

UNIT 4: Classes and Object (8 Hours)

Generating permutations, Stack, Queue, Circular Queue, Abstract datatypes, classes and objects, Classes and objects in Python, User defined lists, Search trees, Tree, Graph, Hashing

UNIT 5: Algorithm (7 Hours)

Asymptotic Notation – Big-O, Big Omega, Big Theta Notation, Memorization and dynamic programming, Grid paths, longest common subsequence, Matrix multiplication, Algorithms, and programming: simple gcd, improving naive gcd, Euclid's algorithm for gcd.

Reference Books:

1. Guido van Rossum and Fred L. Drake Jr, An Introduction to Python – Revised and updated for Python 3.2, Network Theory Ltd., 2011
2. Allen B. Downey, "Think Python: How to Think Like a Computer Scientist, 2nd edition, Updated for Python 3, Shroff/ OReilly Publishers, 2016
3. Robert Sedgewick, Kevin Wayne, Robert Dondero, Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd., 2016

Semester – V: Departmental Elective – II: Specialization – Design and Analysis

Subject Code: KME 057	Mechanical Vibrations	L T P : 3 0 0	Credits: 3

Course Outcome: Student will be able to		Bloom Taxonomy
CO 1	Understand fundamentals of mechanical vibrations along with their classification.	K2
CO 2	Differentiate among single, two and multiple degree of freedom (DOF) systems.	K3
CO 3	Analyze, predict and measure the performance of systems undergoing single, two and multiple DOF.	K4
CO 4	Design systems with optimized vibration absorption capabilities.	K4
CO 5	Apply the fundamentals to the real life problems like whirling of shaft	K3
CO 6	Solve complicated mathematical models using Numerical methods and software applications.	K4

UNIT – I **(10 Hours)**

Introduction, Classification of Vibration Systems, Harmonic motion, Vector representation of harmonic motion, Natural frequency & response, Effects of vibration, superposition of simple harmonic motions, beats, Fourier analysis-analytical method.

Single Degree Freedom System, Equation of motion, Newton's method, D'Alembert's principle, Energy method etc., Free vibration, Natural frequency, Equivalent systems, Displacement, Velocity and acceleration, Response to an initial disturbance, Torsional vibrations, Damped vibrations, Vibrations of systems with viscous damping, Logarithmic decrement, Energy dissipation in viscous damping.

UNIT – II **(8Hours)**

Single Degree Freedom: Forced Vibration Forced vibration, Harmonic excitation with viscous damping, steady state vibrations, Forced vibrations with rotating and reciprocating unbalance, Support excitation, Vibration isolation, Transmissibility, Vibration measuring instruments, Displacement, velocity, and acceleration measuring instruments

UNIT- III **(8Hours)**

Two Degree Freedom systems Introduction, Principal modes, Double pendulum, Torsional system withdamping, Coupled system, Principle of vibration absorber, Undamped dynamic vibration absorbers,Torsional vibration absorber, Centrifugal pendulum absorbers, Vibration isolators and Dampers.

UNIT- IV **(10 Hours)**

Multi-degree Freedom system: Exact Analysis, Undamped free and forced vibrations of multi-degree freedom systems, influence coefficients, Reciprocal theorem, Torsional vibration of multi-degree rotor system, Vibration of gear system, Principal coordinates, Continuous systems- Longitudinal vibrations of bars, Torsional vibrations of circular shafts.

Multi Degree Freedom system: Numerical Analysis by Rayleigh's method, Dunkerley's, Holzer's and Stools methods, Rayleigh-Ritz method.

UNIT- V **(8Hours)**

Critical speed of shafts, Whirling of uniform shaft, Shaft with one disc with and without damping, Multi-disc shafts, Secondary critical speed.

Industrial case studies (any two) involving mechanical vibrations, their impact and performance analysis. Introduction to the vibration analysis using MATLAB.

Books and References:

1. Mechanical Vibrations- V.P. Singh, Dhanpatrai& Co.
2. Mechanical Vibrations- G. K. Grover, Jain Brothers, Roorkee.
3. Mechanical Vibrations- Kelly
4. Mechanical Vibrations- Tse, Morse & Hinkle
5. **Case study Reference#1**: https://www.ijstr.org/final-print/july2018/Vibration-Analysis-Of-Rotating-Machines-With-Case-Studies.pdf
6. **Case study Reference#2:** https://www.researchgate.net/publication/254227083_Case_studies_of_vibrations_in_structures
7. **Case study Reference#3:** https://pdfs.semanticscholar.org/f2b6/39990c4ba52706f43d02fe1c59b9c3fabf2a.pdf
8. **MOOC reference:**https://www.youtube.com/playlist?list=PLSGws_74K01_pG3R7rgtDtrDZBjcTgPdR

Recommended software packages:

1. MATLAB
2. Any modelling and FEA tool like NX, Solid works etc.

Semester – V: Departmental Elective – II: Specialization – Thermal Engineering

Subject Code: KME 058	Fuels and Combustion	L T P : 3 0 0	Credits: 3

	The students will be able to	Blooms Taxonomy
CO1	Understand the properties of different types of fuel with their application.	K2
CO2	Classify different types of fuels.	K2
CO3	Understand the concept of combustion.	K2
CO4	Understand the fundamental concept of air pollution and its control.	K2
CO5	Calculate various properties of the fuels.	K3
CO6	Analyze the flue gases.	K4

Unit-I

Classification and Properties of Fuels:

Fuels-Types and characteristics of fuels-Determination of properties of fuels-Fuel analysis Proximate and ultimate analysis-Calorific value (CV), Gross and net calorific values (GCV,NCV)- Bomb Calorimetry-empirical equations for CV estimation

Solid Fuels:

Origin of coal-Ranking of coal-Washing, cleaning, and storage of coal-Renewable Solid Fuels comparative study of Solid, liquid and gaseous fuels-selection of coal for different industrial applications-carbonization of coal

Unit-II

Liquid Fuels:

Origin of crude oil-composition of crude petroleum-classification of crude petroleum-Removal of salt from crude oil-processing of crude petroleum-Fractionation distillation ADU and VDU Cracking-Hydrotreatment and Reforming

Gaseous Fuels:

Rich and lean gas-Wobbe index-Natural gas-Dry and wet natural gas-Foul and sweet NG-LPGLNG-CNG-Methane-Producer Gas-Water gas-Coal Gasification-Gasification Efficiency

Unit-III: Combustion and Flames Propagation

Chemical composition– Flue gas analysis, Dew point of products, Stoichiometry, Stoichiometry relations, theoretical air required for complete combustion, Enthalpy of formation, Heating value of fuel, Adiabatic flame Temperature, Chemical equilibrium.

Flame stability, Burning velocity of fuels, Measurement of burning velocity, Factors affecting the burning velocity, Flame Propagation – Solid, Liquid & Gaseous Fuels Combustion, Flame Temperature– Theoretical, Adiabatic & Actual, Ignition Limits, Limits of Inflammability.

Unit-IV: Combustion Equipment

Analysis of flue gases by Orsat apparatus-Combustion of solid fuels-grate firing and pulverized fuel firing system-Fluidized bed combustion-Circulating fluidized bed boiler, Oil Burners, Gas Burners, Factors affecting burners and combustion, Combustion in I.C. Engines, Combustion in gas turbine and jet engines

Unit-V: Air Pollution

Types of pollution, Combustion generated air pollution, Effects of air pollution, Pollution of fossil fuels and its control, Pollution from automobiles and its control, Emission by diesel engines, Emission Standards.

Text book (s):

1. Kenneth K.K., Principles of Combustion, 2nd ed., Wiley Publications, USA, 2012
2. Sharma and Chander Mohan, Fuels and combustion, Tata McGraw Hill
3. Phillips H.J., Fuels-solid, liquid, and gases–Their analysis and valuation, 1st ed., Foster Press, USA, 2010

Reference Books:

1. Speight J.G., The Chemistry and Technology of Coal, 3rd ed., Taylor and Francis Ltd., USA, 2016
2. Sarkar S., Fuels and combustion, 3rd ed., Universities Press, India, 2009

Semester – V: Departmental Elective – II: Specialization – Automobile Engineering

Subject Code: KAU 052	Automotive chassis and suspension	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand different types of automotive chassis and frames used in automobiles.	K2
CO-2	Understand transmission and drive line components used in automobile.	K2
CO-3	Understand the axles and types of steering system in automobile.	K2
CO-4	Understand the constructional features of barking, suspension system, wheels and tyres in automobile application.	K2
CO-5	Understand the recent advancements made in chassis components of automobile.	K2
CO-6	Apply the concepts of braking and steering system to design the same for automobile application.	K3

Unit I

Chassis Layouts and Frames

Definition of Chassis, Types of Chassis Layout with reference to Power Plant Location and Drive

Automotive Frames - Material Selection and its Constructional Details, Various types, Different Loads acting on Frame, Testing of Automotive Frames.

Unit II

Transmission: Clutches- Requirements and its types, Gear Box: Need and requirements, Types of manual gear boxes, Gear ratio Calculation.

Drive Line: Propeller Shaft - Design Considerations & Constructional Details, Universal Joints, Constant Velocity Joints, Hotchkiss Drive, Torque Tube Drive, Radius Rods and Stabilizers, Final drive - Different types, Multi-axle Vehicles, Differential - Working Principle and Constructional Details, Non–Slip Differential, Differential Locks.

Unit III

Suspension System: Need; factors influencing ride comfort; types; suspension springs-leaf spring, coil spring & torsion bar; spring materials; independent suspension; rubber suspension; pneumatic suspension; hydraulic suspension, shock absorbers-liquid & gas filled.

Braking Systems: Stopping Distance, Braking Efficiency, Weight Transfer during Braking, Drum Brakes - Constructional Details, Leading and Trailing Shoe, Braking Torque, Disc Brake - Types and Constructional Details, Hydraulic Braking System, Pneumatic Braking System, Power–Assisted Braking System, Factors affecting brake performance, operating temperature, Area of brake lining, clearance.

Unit IV

Axles: Live and Dead Axles, Constructional Details, Different Types of Loads acting on Drive Axles, Rear Axle Shaft Supporting Types: Semi Floating, Full Floating, Three Quarter Floating, Axle Housings and Types

Steering System: Types of Front Axles and Stub Axles, Front Wheel Geometry, Condition for True Rolling Motion of Wheels during Steering, Steering Mechanisms, Steering Error Curve, Steering Linkages, Different Types of Steering Gears, Slip Angle, Over Steer and Under Steer, Reversible and Irreversible Steering, Hydraulic Power Assisted Steering, Turning Radius Calculation.

Unit V

Wheels and Tyres: Types of Wheels, Construction, Structure and Function, Forces acting on wheels, Wheel Dimensions, Wheel Balancing, and Wheel Alignment. Structure and Function of Tyres, Static and Dynamic Properties of Pneumatic Tyres, Types of Tyres, Materials, Tyre Section & Designation, Factors affecting Tyre Life, Tyre Rotation.

Bearings: Functions; classification of bearings; bearing materials; automotive bearings.

Recent Trends in Chassis Systems: Special Steering Columns, 4 wheel steering system, Electric Power Steering, Anti–Lock Braking System, Traction Control Systems, Electronic Brake force Distribution Systems, Corner Stability Control, Hill Assist, and Autonomous Braking System.

Text Books:

1. Automobile engineering", Dr. Kripal Singh.
2. Automobile engineering" R.B. Gupta, SatyaPrakashan.

References:

1. Heldt P.M., "Automotive chassis", Chilton Co., New York.
2. Giles J.G., "Steering, Suspension and tyres", Iliffe Book Co., London.
3. A.K. Babu, Automotive Mechanics, Khanna Publishing House

Subject Code: KME 601	Refrigeration & Air Conditioning	L T P : 3 1 0	Credits: 4

The students will be able to		Blooms Taxonomy
CO1	Understand the basics concepts of Refrigeration & Air-Conditioning and its future prospects.	K2
CO2	Explain the construction and working of various components in Refrigeration & Air-Conditioning systems.	K2
CO3	Understand the different types of RAC systems with their respective applications.	K2
CO4	Apply the basic laws to the thermodynamic analysis of different processes involved in Refrigeration and Air-Conditioning.	K3
CO5	Apply the basic concepts to calculate the COP and other performance parameters for different RAC systems	K3
CO6	Analyze the effects of performance parameters on COP.	K4

Unit-1 **8 Hours**

Refrigeration:

Introduction to refrigeration system, Methods of refrigeration, Unit of refrigeration, Refrigeration effect, Carnot refrigeration cycle, Refrigerator and Heat Pump, C.O.P.

Air Refrigeration cycle:

Open and closed air refrigeration cycles, Reversed air Carnot cycle, Bell Coleman or Reversed Joule air refrigeration cycle, Need of Aircraft refrigeration, Classification of aircraft refrigeration system. Boot strap refrigeration, Regenerative, Reduced ambient, Dry air rated temperature (DART).

Unit-2 **8 Hours**

Vapour Compression System:

Reversed vapour Carnot cycle, limitation of Reversed vapour Carnot cycle, Simple vapour compression cycle, Analysis of vapour compression cycle, Use of T-S and P-H charts, Effect of change in suction and discharge pressures on C.O.P, Effect of sub cooling of condensate & superheating of refrigerant vapour on C.O.P of the cycle, Actual vapour compression refrigeration cycle,

Multistage System:

Multistage vapour compression system requirement, Different configuration of multi pressure system, Removal of flash gas, Intercooling, Multi evaporator system, Cascade system.

Unit-3 **8 Hours**

Vapour Absorption system;

Working Principal of vapour absorption refrigeration system, Comparison between absorption & compression systems, Elementary idea of refrigerant absorbent mixtures, Temperature – concentration diagram & Enthalpy – concentration diagram , Adiabatic mixing of two streams, Ammonia – Water vapour absorption system, Lithium- Bromide water vapour absorption system, Comparison, Three fluid system.

Refrigerants:
Classification of refrigerants, Nomenclature, Desirable properties of refrigerants, Common refrigerants, Secondary refrigerants, and Environment friendly refrigerants, Anti-freeze solution, Phase changing materials, Ozone layer depletion and global warming considerations of refrigerants, Selection of refrigerants, Future Refrigerants like Hydrofluoro-Olefines

Unit-4 **8 Hours**

Air Conditioning:
Introduction to air conditioning, Psychrometric properties and their definitions, Psychrometric chart, Different Psychrometric processes, Air Washers, Cooling towers & humidifying efficiency, Thermal analysis of human body, Effective temperature and comfort chart, Cooling and heating load calculations, Selection of inside & outside design conditions, Heat transfer through walls & roofs, Infiltration & ventilation, Internal heat gain, Sensible heat factor (SHF), By pass factor, Grand Sensible heat factor (GSHF), Apparatus dew point (ADP).

Window air Conditioner, Simple air conditioning system, Air conditioning system with ventilation.

Unit-5 **8 Hours**

Refrigeration System Equipment:
Compressors, Condensers, Expansion Devices and Evaporators, Elementary knowledge of transmission and distribution of air through ducts and fans,

Application:
Food preservation, Transport refrigeration, Cold storage, Refrigerates Freezers, Ice plant, Water coolers, Comfort and Industrial air conditioning Refrigeration.

Other systems:
Cryogenic liquefaction and refrigeration systems, Brief introduction of Thermo-electric refrigeration system, Steam jet refrigeration system, Vortex tube refrigeration system, Magnetic refrigeration system.

Reference Books:
1. Refrigeration and Air conditioning by C.P Arora, McGraw-Hill
2. Refrigeration and Air conditioning, by Manohar Prasad, New Age International (P) Ltd. Pub.
3. Refrigeration and Air conditioning by R.C. Arora, PHI
4. Principles of Refrigeration by Roy J. Dossat. Pearson Education
5. Refrigeration and Air conditioning by Stoecker& Jones. McGraw-Hill
6. Refrigeration and Air conditioning by Arora&Domkundwar. DhanpatRai
7. Thermal Environment Engineering. By Kuhen, Ramsey &Thelked

Subject Code: KME 602	Machine Design	L T P : 3 1 0	Credits: 4

Course Outcomes: The student will be able to		Blooms Taxonomy
CO 1	Recall the basic concepts of Solid Mechanics to understand the subject.	K2
CO 2	Classify various machine elements based on their functions and applications.	K2
CO 3	Apply the principles of solid mechanics to machine elements subjected to static and fluctuating loads.	K3
CO 4	Analyze forces, bending moments, twisting moments and failure causes in various machine elements to be designed.	K4
CO 5	Design the machine elements to meet the required specification.	K5

Unit I **8 Hours**

Introduction

Definition, Design requirements of machine elements, Design procedure, Standards in design, Standards designation of carbon & alloy steels, Selection of preferred sizes, Selection of materials for static and fatigue loads, Design against Static Load

Design against Fluctuating Loads

Cyclic stresses, Fatigue and endurance limit, Stress concentration factor, Stress concentration factor for various machine parts, Design for finite & infinite life, Soderberg, Goodman, Gerber criteria

Unit II **8 Hours**

Riveted Joints

Riveting methods, materials, Types of rivet heads, Types of riveted joints, Caulking and Fullering, Failure of riveted joint, Efficiency of riveted joint, Design of boiler joints, Eccentric loaded riveted joint

Welded Joints

Stress relieving of welded joints, Butt Joints, Fillet Joints, Strength of Butt Welds, Strength of parallel fillet welds, Strength of transverse fillet welds

Shafts

Cause of failure in shafts, Materials for shaft, Stresses in shafts, Design of shafts subjected to twisting moment, bending moment and combined twisting and bending moments, Shafts subjected to fatigue loads, Design for rigidity, Keys, Types of keys, Selection of square and flat keys, Strength of sunk key

Unit III **8 Hours**

Spur Gears

Tooth forms, System of gear teeth, contact ratio, Standard proportions of gear systems, Interference in involute gears, Backlash, Selection of gear materials, Gear manufacturing methods, Design considerations, Beam strength of gear tooth, Dynamic tooth load, Wear strength of gear tooth, Failure of gear tooth, Design of spur gears, AGMA and Indian standards.

Helical Gears

Terminology, Proportions for helical gears, Force components on a tooth of helical gear, Virtual number of teeth, Beam strength and wear strength of helical gears, Dynamic load on helical gears, Design of helical gears.

Introduction, Classification and Applications of Bevel & Worm Gears

Unit IV **8 Hours**

Sliding Contact Bearing

Types, Selection of bearing, Plain journal bearing, Hydrodynamic lubrication, Properties and materials, Lubricants and lubrication, Hydrodynamic journal bearing, Heat generation, Design of journal bearing.

Rolling Contact Bearing

Advantages and disadvantages, Types of ball bearing, Thrust ball bearing, Types of roller bearing, Selection of radial ball bearing, Bearing life, Selection of roller bearings, Dynamic equivalent load for roller contact bearing under constant and variable loading, Reliability of Bearing.

Unit V **8 Hours**

IC Engine Parts

Selection of type of IC engine, General design considerations, Design of Cylinder and cylinder head; Design of piston, piston ring and gudgeon pin;

Friction Clutches

Clutches, Difference between coupling and clutch, Single plate friction clutch, Torque transmitting capacity, Multi-Disk Clutches, Friction Material

Note: Design data book is allowed in the examination

Text Books:

1. Design of Machine Elements-V.B. Bhandari, McGraw Hill Co.
2. Design of Machine Elements, Sharma and Purohit, PHI.

Reference Books:

1. Mechanical Engineering Design, 9e – Joseph E. Shigely, McGraw Hill Education.
2. Machine Design-Maleev and Hartman, CBS Publishers.
3. Design of Machine Design-M.F. Spott, Pearson Education.
4. Elements of Machine Component Design, Juvinal&Marshek, John Wiley & Sons.
5. Machine design, Robert L. Norton, Pearson Education
6. Theory & Problem of Machine Design (Schaum's Outline Series) Hall, Holowenko, Laughlin, Tata McGraw Hill Co.
7. Machine Design-Sharma and Agrawal, S.K. Kataria& Sons.
8. Machine Design, U C Jindal, Pearson Education.

Subject Code: KME 603	Theory of Machines	L T P : 3 1 0	Credits: 4

Course Outcomes: The students will be able to		Blooms Taxonomy
CO1	Understand the principles of kinematics and dynamics of machines.	K2
CO2	Calculate the velocity and acceleration for 4-bar and slider crank mechanism	K3
CO3	Develop cam profile for followers executing various types of motions	K3
CO4	Apply the concept of gear, gear train and flywheel for power transmission	K3
CO5	Apply dynamic force analysis for slider crank mechanism and balance rotating & reciprocating masses in machines.	K3
CO6	Apply the concepts of gyroscope, governors in fluctuation of load and brake & dynamometer in power transmission	K3

Unit I **(09 Hours)**

Introduction, mechanisms and machines, kinematics and kinetics, types of links, kinematic pairs and their classification, types of constraint, degrees of freedom of planar mechanism, Grubler's equation, mechanisms, inversion of four bar chain, slider crank chain and double slider crank chain.

Velocity analysis: Introduction, velocity of point in mechanism, relative velocity method, velocities in four bar mechanism, instantaneous center.

Acceleration analysis: Introduction, acceleration of a point on a link, acceleration diagram, Corioli's component of acceleration, crank and slotted lever mechanism,.

Unit II **(10 Hours)**

Cams: Introduction, classification of cams and followers, cam profiles for knife edge, roller and flat faced followers for uniform velocity, uniform acceleration

Gears and gear trains: Introduction, classification of gears, law of gearing, tooth forms and their comparisons, systems of gear teeth, length of path of contact, contact ratio, minimum number of teeth on gear and pinion to avoid interference, simple, compound, reverted and planetary gear trains, sun and planet gear train.

Unit III **(08 Hours)**

Force analysis: Static force analysis of mechanisms, D'Alembert's Principle, dynamics of rigid link in plane motion, dynamic force analysis of planar mechanisms, piston force and crank effort. Turning moment on crankshaft due to force on piston, Turning moment diagrams for single cylinder double acting steam engine, four stroke IC engine and multi-cylinder engines, Fluctuation of speed, Flywheel.

Unit IV **(09 Hours)**

Balancing: Introduction, static balance, dynamic balance, balancing of rotating masses, two plane balancing, graphical and analytical methods, balancing of reciprocating masses, balancing of single cylinder engine.

Governors: Introduction, types of governors, characteristics of centrifugal governors, gravity controlled and spring controlled centrifugal governors, hunting of centrifugal governors, inertia governors. Effort and Power of governor

Unit V **(09 Hours)**

Brakes and dynamometers: Introduction, Law of friction and types of lubrication, types of brakes, effect of braking on rear and front wheels of a four wheeler, dynamometers, belt transmission dynamometer, torsion dynamometer, hydraulic dynamometer

Gyroscope: Space motion of rigid bodies, angular momentum, gyroscopic couples, gyroscopic stabilization, ship stabilization, stability of four wheel and two wheel vehicles moving on curved paths.

Text / Reference Books

1. Kinematics and dynamics of machinery: Wilson and Sadler, Third edition, Pearson.
2. Theory of Mechanisms and Machines: Amitabh Ghosh and Ashok Kumar Mallik, Third Edition Affiliated East-West Press.
3. Theory of Machines and Mechanisms: Joseph Edward Shigley and John Joseph Uicker, Jr. Oxford University Press
4. Kinematics and dynamics of machinery: R L Norton, McGraw Hill
5. Theory of Machines: S.S. Rattan, McGraw Hill
6. Theory of Machines: Thomas Bevan, CBS Publishers.

Suggested Software

MechAnalyzer

Subject Code: KME 651	Refrigeration & Air Conditioning Lab	L T P : 0 0 2	Credits: 1

The students will be able to:		Blooms Taxonomy
CO1	Determine the performance of different refrigeration and air-conditioning systems.	K3
CO2	Apply the concept of psychrometry on different air cooling systems.	K3
CO3	Interpret the use of different components, control systems and tools used in RAC systems	K3
CO4	Demonstrate the working of practical applications of RAC systems.	K2

Minimum eight experiments out of the following:

1. Experiment on refrigeration test rig and calculation of various performance parameters.
2. Experiment on air-conditioning test rig & calculation of various performance parameters.
3. Study of Psychrometer and determination of humidity of air using Sling Psychrometer.
4. To study and perform experiment on vapour absorption apparatus.
5. To study the air washer and perform different psychometric processes on air washer.
6. Study of desert coolers and determine the change in temperature and humidity of ambient air.
7. Handling, use and familiarization with refrigeration tools and accessories such as: Tube cutter; Tube bender [spring type]; Flaring tool; Swaging tool; Pinch off etc.
8. Study of window air conditioner.
9. Study of Hermetically sealed compressor.
10. To study basic components and control devices of refrigeration and air-conditioning system.
11. Experiment on Ice-plantand calculation of various performance parameters.
12. Visit of a central air conditioning plant and its detailed study.
13. Visit of cold-storage and its detailed study.

Subject Code: KME 652	Machine Design Lab	L T P : 0 0 2	Credits: 1

Course Outcomes: The student will be able to		Blooms Taxonomy
CO-1	Apply the principles of solid mechanics to design various machine Elements subjected to static and fluctuating loads.	**K3**
CO-2	Write computer programs and validate it for the design of different machine elements	**K4**
CO-3	Evaluate designed machine elements to check their safety.	**K5**

A Design of Machine Elements

1. Design a knuckle joint subjected to given tensile load.
2. Design a riveted joint subjected to given eccentric load.
3. Design of shaft subjected to combined constant twisting and bending loads
4. Design a transverse fillet welded joint subjected to given tensile load.
5. Design & select suitable Rolling Contact Bearing for a shaft with given specifications
6. Design a cylinder head of an IC Engine with prescribed parameters.
7. Design of Piston & its parts of an IC Engine

B. Computer Programs for conventional design

Computer and Language

Students are required to learn the basics of computer language such as C/C++/MATLAB so that they should be able to write the computer program.

1. Design a pair of Spur Gear with given specifications to determine its various dimensions using Computer Program in C/C++.
2. Design a pair of Helical Gear with given specifications to determine its various dimensions using Computer Program in C/C++.
3. Design of Sliding Contact Bearing with given specifications & determine its various parameters using Computer Program in C/C++.

Subject Code: KME 653	Theory of Machines Lab	L T P : 0 0 2	Credits: 1

The students will be able to:		Blooms Taxonomy
CO1	Demonstrate various mechanisms, their inversions and brake and clutches in automobiles	K2
CO2	Apply cam-follower mechanism to get desired motion of follower.	K3
CO3	Apply the concepts of gears and gear train to get desired velocity ratio for power transmission.	K3
CO4	Apply the concept of governors to control the fuel supply in engine.	K3
CO5	Determine the balancing load in static and dynamic balancing problem	K3

List of Experiments

(Minimum eight experiments out of the following)

NOTE: Student has to write computer program in C / C++ / Python and to run to compute the output values for at least ONE experiments.

1. To study various types of kinematics links, pairs, chains & Mechanisms
2. To study Whitworth Quick Return Motion Mechanisms, Reciprocating Engine Mechanism, and Oscillating Engine Mechanism
3. To study of inversions of four bar linkage
4. To study of inversions of single/double slider crank mechanisms
5. To study various types of gear (Helical, cross helical, worm, bevel gear) and gear profile (involute and cycloidal) and condition for interference Helical, cross helical, worm, bevel gear
6. To compute the output velocity invarious gear trains
7. To study gyroscopic effects through models
8. To determine gyroscopic couple on Motorized Gyroscope
9. To perform experiment on dead weight type governor to prepare performance characteristic Curves, and to find stability & sensitivity
10. To perform experiment on spring controlled governor to prepare performance characteristic Curves, and to find stability & sensitivity
11. To determine whirling speed of shaft theoretically and experimentally
12. To perform the experiment for static / dynamic balancing
13. To perform experiment on brake
14. To perform experiment on clutch
15. To perform the experiment for static / dynamic balancing.
16. To perform experiment on longitudinal vibration
17. To perform experiment on transverse vibration

Semester – VI: Departmental Elective – III: Specialization – Manufacturing and Automation

Subject Code: KME 061	Nondestructive Testing	L T P : 3 0 0	Credits: 3

Course Outcome: Student will be able to		Bloom Taxonomy
CO 1	Understand the concept of destructive and Non-destructive testing methods.	K2
CO 2	Explain the working principle and application of die penetrant test and magnetic particle inspection.	K2
CO3	Understand the working principle of eddy current inspection.	K2
CO 4	Apply radiographic techniques for testing.	K3
CO 5	Apply the principle of Ultrasonic testing and applications in medical and engineering areas.	K3

Unit-I:

Introduction to NDT, DT, advantages & limitations of NDT, classification of NDT methods, Comparison with DT, Terminology, Flaws and Defects. Scope of NDT.Codes, Standards and Certifications in NDT.

Visual Inspection– Equipment used for visual inspection, Borescopes, Application of visual inspection tests in detecting surface defects and their interpretation, advantages & limitations of visual inspection, Visual Inspection in Welding.

Unit-II:

Liquid Penetrant Testing – Principle, Scope, Testing equipment, Advantages, Limitations, types of penetrants and developers, standard testing procedure, Zyglo test, Illustrative examples and interpretation of defects.

Magnetic Particle Inspection – Principle, Scope, Testing equipment, Advantages, Limitations, Application of MPI & standard testing procedure, DC & AC magnetization, Skin Effect, different methods to generate magnetic fields, Illustrative examples and interpretation of defects.

Unit-III:

Radiographic Testing – Introduction to electromagnetic waves and radioactivity, various decays, Attenuation of electromagnetic radiations, Photoelectric effect, coherent scattering and Incoherent scattering, Beam geometry.

X-ray Radiography – Principle, equipment & methodology, applications, source, types of radiations and limitations; γ-ray Radiography – Principle, equipment, γ-ray source & technique; Radiography Image Quality Indicators, Film Processing, advantages of γ-ray radiography over X-ray radiography. Precautions against radiation hazards.

Unit-IV:

Ultrasonic Testing – Introduction, Principle, Piezoelectricity and Piezoelectric Transducers, Wave propagation, Ultrasonic probes, selection of angle probes, Acoustic Impedance, Reflection and transmission coefficient, Snell's law, standard testing procedure & calibration, advantages & limitations. Data representation - A-scan, B-scan, C-scan. Applications in inspection of welded joints, castings, forgings and dimensional measurements. Introduction to TOFD & Phased Array Ultrasonic Testing.

Unit-V:

Special NDT Techniques:

Eddy Current Inspection– Introduction, Principle, Methods, scope, Equipment, types of probes, Sensitivity, standard testing procedure, advanced ECT methods, advantages and limitations.

Acoustic Emission Technique– Introduction, Types of AE signal, Principle, Advantages & Limitations, Interpretation of Results, Applications.

Holography, Thermography– Introduction, Principle, advantages, limitations and applications.

Books and References:

1. Non-Destructive Testing and Evaluation of Materials, by- Prasad, McGraw Hill Education.
2. Practical Non-destructive Testing, by- Baldev Raj, T. Jayakumar, M. Thavasimuthu, Woodhead Publishing.
3. Non-Destructive Testing Techniques, by- Ravi Prakash, New Age International.
4. Non destructive Testing Handbook, by Robert C. McMaster, American Society for Nondestructive.
5. Introduction to Non destructive Testing: A Training Guide, by- Paul E. Mix, wiley.
6. Electrical and Magnetic Methods of Non-destructive Testing, by- J. Blitz, springer.
7. Practical non destructive testing by Raj, Baldev.
8. Basics of Non-Destructive Testing, by Lari& Kumar, KATSON Books.
9. ASME Sec. V, boiler and pressure vessel code

Semester – VI: Departmental Elective – III: Specialization – Automation and Industry 4.0

Subject Code: KME 062	Artificial Intelligence	L T P : 3 0 0	Credits: 3

Course Outcomes: Students are able to		Bloom's Taxonomy
CO 1	Understand concepts of Artificial Intelligence	K2
CO 2	Solve problem by Search-I & Search-II	K3
CO 3	Understand Knowledge representation	K2
CO 4	Apply concepts of Learning methods	K3
CO 5	Analyse Decision Networks	K4
CO 6	Build planning graphs	K5

Unit 1: **(9Hours)**

Introduction of Artificial Intelligence, Intelligent Agents, and Behaviors of Artificial Agents, Structure of Intelligent Agents. Problem solving and state space search, Uninformed Search, Heuristic search, Best-First Search, Heuristic Functions, Constraints satisfaction problem, Iterative Improvement Algorithms.

(Recommended lab practice sessions: Games as Search Problems, Alpha-Beta Pruning, State-of-the-Art Game Programs.)

Unit 2: **(8Hours)**

Introduction to Knowledge Representation, Propositional Logic, 1st order logic-I, 1st order logic-II, Inference in First-Order Logic, Using First-Order Logic, Building a Knowledge Base, Logical Reasoning Systems; Indexing, Retrieval, and Unification, Inference in FOL-II, Answer Extraction.

Unit 3: **(9Hours)**

Procedural control of reasoning, reasoning under uncertainty, Bayesian Networks, Decision Networks, Uncertain knowledge and reasoning, The Axioms of Probability, Bayes' Rule and Its Use, Probabilistic Reasoning Systems, Making Simple Decisions, Making Complex Decisions, Introduction to Planning, Practical Planning and Acting, Inductive Learning, Learning from Observations.

Unit 4: **(7Hours)**

Neural Networks: Learning in Neural Networks, How the Brain Works, Perceptron, Multilayer Feed-Forward Networks, Applications of Neural Networks, Introduction to Learning, Kinds of Learning, Supervised and Unsupervised Learning, Clustering, Reinforcement Learning.

Learning a Function, Aspects of Function Learning, and Types of function learning aspects: Memory, Averaging and Generalization, Example problems based on Function Learning.Learning methods, Nearest Neighbor, Decision Trees, and Neural Networks.

Unit 5: **(7Hours)**

Intelligent Agents, Types of Communicating Agents, A Communicating Agent, Practical Natural Language Processing: Practical Applications, Efficient Parsing, Scaling Perception: Image-Processing Operations for Early Vision, Using Vision for Manipulation and Navigation, Speech Recognition. Robotics: Tasks: What

Are Robots Good For? Parts: What Are Robots Made Of? Architectures, Configuration Spaces: A Framework for Analysis, Navigation and Motion Planning

Text Book:

1. Stuart Russell, Peter Norvig, “Artificial Intelligence – A Modern Approach”, Pearson Education

Reference Books:

2. Elaine Rich and Kevin Knight, “Artificial Intelligence”, McGraw-Hill
3. E Charniak and D McDermott, “Introduction to Artificial Intelligence”, Pearson Education
4. Dan W. Patterson, “Artificial Intelligence and Expert Systems”, Prentice Hall of India,

Semester – VI: Departmental Elective – III: Specialization – Design and Analysis

Subject Code: KME 063	Tribology	L T P : 3 0 0	Credits: 3

Course Outcome: Student will be able to		Bloom Taxonomy
CO 1	Identify and explain various friction and wear mechanisms.	K2
CO 2	Select proper lubricants for different applications.	K3
CO 3	Select suitable lubrication methods in different bearings.	K3
CO 4	Study the surfaces coating techniques for reduction of wear.	K3
CO 5	Analyze the impact of friction in various kinematic pairs.	K4

UNIT –I Lubrication and Lubricants

Introduction to tribology, tribology in industry, basics modes of lubrication, oil viscosity, temperature and pressure dependence of viscosity, Viscosity index, viscosity measurement, properties of lubricants, temperature characteristics of lubricants, lubricant impurities and contaminants, mineral oils based lubricants, synthetic oils based lubricants, emulsions and aqueous lubricants, greases, and lubricant additives.

UNIT –II Friction and Wear

Friction-causes of friction, theories of dry friction; adhesion theory, abrasive theory, junction growth theory, laws of rolling friction, friction measurement, friction instabilities.

Wear- classification; abrasive wear, erosive wear, cavitation wear, adhesive wear, corrosive wear, oxidative wear, fatigue wear, factors affecting wear, measurement of wear, theories of wear, approaches to friction control and wear prevention.

UNIT –III Lubrication of Bearings

Theory of hydrodynamic lubrication, mechanism of pressure development in oil film, jet lubrication, mist lubrication, lubrication utilizing under race passage, concept of journal bearing, minimum oil film thickness, porous bearings, flat plate thrust bearing, tilting pad bearings, hydrostatic lubrication, squeeze film lubrication, elasto-hydrodynamic lubrication, rolling element bearings, gas lubricated bearings, and hybrid bearings.

UNIT –IV Solid Lubrication and Surface Treatment

Lubrication by solids, friction and wear characteristics of lamellar solids, reduction of friction by soft metallic films, deposition methods of solid lubricants, techniques for producing wear resistant coatings, characteristics of wear resistant coatings.

UNIT –V Friction, Lubrication and Wear in Kinematic pairs

The concept of friction angle, friction stability, friction in slideways, friction in screws with square threads, friction in screws with triangular threads, mechanism and operation of plate clutch, cone clutch, rim clutch, centrifugal clutch, and belt drives, tribo design aspects of labyrinth seals, analysis of line contact lubrication, analysis of point contact lubrication, cam follower system, traction in the contact zone, and hysteresis losses.

Books and References:

1. Fundamentals of Engineering Tribology with Applications by Harish Hirani, Cambridge English (2017)

2. Applied Tribology (Bearing Design and Lubrication), by Michael M Khonsari, John Wiley & Sons (2001).
3. Principles of Tribology, by J Halling, The Macmillan Press Ltd,London, (1975).
4. Friction, Wear, Lubrication:A textbook in Tribology, by Ludema K C, CRC Press, (2010).
5. Fundamentals of Machine Elements, B.J. Hamrock, B.O. Jacobson & S.R. Schmid, McGraw-Hill Inc., (1998).
6. Fundamentals of Mechanical Component Design, by K.S. Edwards & R.B. McKee, McGraw-Hill Inc., (1991).
7. Mechanical Engineering Design by J.E. Shigley and C R Mischke, Tata McGraw-Hill Publishing Company Limited, (2003).
8. Tribophysics, by N.P. Suh Prentice-Hall, (1986).
9. Friction, Wear, Lubrication: A Textbook in Tribology, by Kenneth C Ludema, LayoAjayi, CRC Press (2019).

Semester – VI: Departmental Elective – III: Specialization – Thermal Engineering

Subject Code: KME 064	Gas Dynamics and Jet Propulsion	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO1	Understand the concept of compressible fluid flow and flow through variable area ducts.	K2
CO2	Understand the basic principle and types of jet and rocket propulsion.	K2
CO3	Apply the basic laws for the investigation of flow through ducts.	K3
CO4	Apply the basic laws for the thermodynamics analysis of jet and rocket propulsion.	K3
CO5	Analyze the compressible flow through variable area ducts.	K4

UNIT -I:
Compressible flow, definition, Mach waves and Mach cone, stagnation states, Mass, momentum and energy equations of one-dimensional flow.

UNIT-II:
Isentropic flow through variable area ducts, nozzles and diffusers, subsonic and supersonic flow variable area ducts, choked flow, Area-Mach number relations for isentropic flow.

UNIT -III:
Non-isentropic flow in constant area ducts, Rayleigh and Fano flows, Normal shock relations, oblique shock relations, isentropic and shock tables.

UNIT -IV:
Theory of jet propulsion, thrust equation, thrust power and propulsive efficiency, Operating principle and cycle analysis of ramjet, turbojet, turbofan and turboprop engines.

UNIT -V:
Types of rocket engines, propellants & feeding systems, ignition and combustion, theory of rocket propulsion, performance study, staging, terminal and characteristic velocity, space flights.

Books and References:
1. Ahmed F. El-Sayed, Aircraft Prpoulsion and Gas Turbine Engines, CRC Press, 2008.
2. H.S. Mukunda, “Understanding Aerospace Chemical Propulsion”, Interline Publishing,2004.
3. Hill P. and Peterson C., Mechanics & Thermodynamics of Propulsion, Addison Wesley,1992.
4. Zucrow N. J., Aircraft and Missile Propulsion, Vol.I& II, John Wiley, 1975.
5. Sutton G.P., Rocket Propulsion Elements, John Wiley, New York, 1986.

Semester – VI: Departmental Elective – III: Specialization – Automobile Engineering

Subject Code: KAU 061	Automotive Electrical and Electronics	L T P : 3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand the basic concepts of electrical systems used in automobile.	K2
CO-2	Understand the constructional features of charge storage devices and methods to test these devices for their healthy operation.	K2
CO-3	Understand the principles and characteristics of charging and starting system of automobile and study the various faults occurring in system.	K2
CO-4	Understand the ignition and auxiliary system- types & constructional features used in automobile.	K2
CO-5	Describe the principles and architecture of electronics systems and its components present in an automobile related to data transfer, instrumentation, control, and security systems.	K2
CO-6	Understand latest trends developed in electrical and electronic systems of automobile and their advantages over conventional technologies.	K2

Unit 1 **[L 8 Hours]**

Introduction to electrical fundamentals – Ohm's Law, Kirchhoff's Law, Capacitance and Inductance, Simple Electric Circuits, Automotive Wiring Harnesses, Insulated and Earth Return System, Positive and Negative Earth Systems, Connectors and its types

Charge storing devices- Principle and construction of Lead Acid Battery, Nickel – Cadmium Battery, Nickel Metal, Hybrid Battery, Sodium Sulphur Battery and Aluminum Air Battery-Choice of Batteries for automotive applications, Characteristics of Battery, Battery Rating, Capacity and Efficiency, Various Tests on Battery, Battery– Charging Techniques. Maintenance of batteries.

Unit 2 **[L 8 Hours]**

Starter Systems- Requirements of Starter Motor, Starter Motor types, construction and characteristics, Starter drive mechanisms, Starter Switches and Solenoids.
Charging system components, Generators and Alternators, types, construction and Characteristics,

Charging System- Voltage and Current Regulation, Cut –out relays and regulators, Charging circuits for D.C. Generator, A.C. Single Phase and Three – Phase Alternator

Unit 3 **[L 8 Hours]**

Automotive Ignition Systems: Spark Plugs, Constructional details and Types, Battery Coil and Magneto– Ignition System Circuit details and Components, Centrifugal and Vacuum Advance Mechanisms, Non– Contact– type Ignition Triggering devices, Capacitive Discharge Ignition, Distributor–less Ignition Systems

Auxiliary Systems: Head Lamp and Indicator Lamp construction and working details, Focusing of head lamps, Anti– Dazzling and Dipper Details, Automotive Wiring Circuits. Indicators and meters, speedometers, electric horn, windshield wiper, electric horn and relay devices.

Unit 4 **[L 8 Hours]**

Automotive Electronics: Automotive networking, Bus system, Advantages of bus systems, requirements of buses, Buses in motor vehicle: CAN, FlexRay, LIN, Ethernet, IP, PSI5, MOST bus and optical fibers/wave guides, Architectures of electronic system.

Control Units: ECM, ABS control unit, Steering Control Unit, SRS control unit, Automatic Air Conditioning Control Unit.

Unit 5 **[L 8 Hours]**

Automotive Sensors and Actuators: Basic principle, Main requirements, Micromechanics, Position sensors, Speed and RPM sensors, Acceleration and vibration sensors, Pressure sensors, Flow meters, Gas sensors, concentration sensors, temperature sensors, Force sensors, Optoelectronics sensors, Sensors for driver assistance systems: Ultrasonic technology, Radar technology, LIDAR sensors Purge Control, Idling Setting Control, Immobilizer System, Stepper motors.

Books:

1. Automotive Electricals by PL Kohli, McGraw Hill Publications.
2. Robert Bosch “Automotive Hand Book”, SAE (8th Edition), 2011.

References:

1. Tom Denton, “Automobile Electrical and Electronic Systems” 4th edition- Routledge - 2012.
2. Barry Hollembeak, “Automotive Electricity and Electronics”, Delmar Cengage Learning; 5th edition, 2011

B. Tech Mechanical Engineering
Evaluation Scheme
Effective in Session 2021-22 (Yet to finalized)

SEMESTER- VII

Sl. No.	Code	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1		HSMC-1/HSMC-2	3	0	0	30	20	50		100		150	3
2		Departmental Elective-IV	3	0	0	30	20	50		100		150	3
3		Departmental Elective-V	3	0	0	30	20	50		100		150	3
4		Open Elective-II	3	0	0	30	20	50		100		150	3
5		Lab-1	0	0	2				25		25	50	1
6		Mini Project or Internship Assessment*	0	0	2				50			50	1
7		Project	0	0	8				150			150	4
8		MOOCs (Essential for Hons. Degree)											
		Total	**9**	**0**	**12**	**21**						**850**	**18**

***The Mini Project or internship (5 - 6 weeks) conducted during summer break after VI semester and will be assessed during VII semester.

SEMESTER- VIII

Sl. No	Code	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1		HSMC-2/HSMC-1	3	0	0	30	20	50		100		150	3
2		Open Elective-III	3	0	0	30	20	50		100		150	3
3		Open Elective-IV	3	0	0	30	20	50		100		150	3
4		Project	0	0	18				100		300	400	9
5		MOOCs (Essential for Hons. Degree)											
		Total	**9**	**0**	**18**	**27**						**850**	**18**

Semester – VII: Departmental Elective – IV (Common for Three Specializations)
Specialization – Manufacturing and Automation
Automation and Industry 4.0
Design and Analysis

Subject Code: KME 071	Additive manufacturing	L T P : 3 0 0	Credits: 3

Course Outcome: Student will be able to		Bloom Taxonomy
CO 1	Understanding the basics of additive manufacturing/rapid prototyping and its advantages and disadvantages	K2
CO 2	Understanding the role of additive manufacturing in the design process and the implications for design.	K2
CO 3	Understanding the processes used in additive manufacturing for a range of materials and applications	K2
CO 4	Understand the various software tools, processes and techniques that enable advanced/additive manufacturing and personal fabrication.	K2
CO 5	Apply knowledge of additive manufacturing for various real-life applications	K3

UNIT I
Introduction
History and Advantages of Additive Manufacturing, Distinction Between Additive Manufacturing and CNC Machining, Types of Additive Manufacturing Technologies, Nomenclature of AM Machines, Direct and Indirect Processes; Prototyping, Manufacturing and Tooling.

Layer Manufacturing Processes: Polymerization, Sintering and Melting, Extrusion, Powder Binder Bonding, Layer Laminate Manufacturing, Other Processes; Aerosol printing and Bio plotter.

UNIT II
Development of Additive Manufacturing Technology
Computer Aided Design Technology, Other Associated Technology, Metal and Hybrid Systems.

Generalized Additive Manufacturing Process Chain; The Eight Steps in Additive Manufacturing, Variation from one AM Machine to Another, Metal System, Maintenance of Equipment, Material Handling Issue, Design of AM.

UNIT III
Additive Manufacturing Processes
Vat Photo polymerization; Materials, Reaction Rates, Photo polymerization Process Modelling, Scan Patterns

Powder Bed Fusion Processes; Material, Powder Fusion Mechanism, Process Parameters and Modeling, powder Handling

Extrusion Based System; Basic principles, plotting and Path Control, Other Systems

Material Jetting; Materials, Material Processing Fundamentals, Material Jetting Machines
Directed Energy Deposition Processes; General DED Process Description, Material Delivery, DED systems, Process Parameters, Processing-Structure-Properties Relationships

UNIT IV: Design & Software Issues
Additive Manufacturing Design and Strategies; Potentials and Resulting Perspectives, AM based New Strategies, Material Design and Quality Aspects for Additive Manufacturing; Material for AM, Engineering Design Rules for AM.

Software Issue for Additive Manufacturing; Introduction, Preparation of CAD Models: The STL file, Problem with STL file, STL files Manipulation, Beyond the STL file, Additional Software to Assist AM

UNIT V
Material Design & Quality Aspects
Machines for Additive Manufacturing, Printers, Secondary Rapid Prototyping processes, Intellectual Property, Product Development, Commercialization, Trends and Future Directions in Additive Manufacturing, Business Opportunities

Applications
Aerospace, Automotive, Manufacturing, Architectural Engineering, Art, Jewellery, Toys, Medical, Biomedical, Dental, Bio-printing, Tissue & Organ Engineering and many others.

Books and References:
1. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, by- Ian Gibson , DSavid W. Rosen , Brent Stucker, Springer.
2. Understanding Additive Manufacturing, by- Andreas Gebhardt, Hanser.
3. Additive Manufacturing, by- AmitBandyopadhyay, Susmita Bose, CRC Press.
4. Rapid Prototyping: Principles and Applications, by -Chee Kai Chua, Kah Fai Leong, Chu Sing Lim.

Semester – VII: Departmental Elective – IV: Specialization – Thermal Engineering

Subject Code: KME 072	HVAC systems	L T P : 3 0 0	Credits: 3

The students will be able to		Bloom Taxonomy
CO1	Understand the basics concepts of HVAC and various HVAC systems.	K2
CO2	Understand the use of refrigerants with their respective applications and its future trends.	K2
CO3	Understand the use of different auxiliary systems used in HVAC systems.	K2
CO4	Apply the basic laws for thermodynamic analysis of different processes involved in HVAC systems.	K3
CO5	Apply the basic concepts to calculate the HVAC loads for different applications.	K3
CO6	Apply the concepts of psychrometry to design HVAC systems for different applications	K3

Unit-I **(8 Hours)**

Advanced Vapour Compression Cycles: Review of vapour compression cycle, Effect of superheating, subcooling, condenser pressure and evaporator pressure on COP, Transcritical cycle, Ejector refrigeration cycle. Presentation of cycle on P-h and T-s chart.

Refrigerants: Classification of Refrigerants, CFC, HFC, HCFC, Azeotropic, Zeotropic, Natural refrigerant, Secondary Refrigerant, Anti-freeze solution, Phase Changing Materials. Desired properties of refrigerants, Requirements for refrigerant, Classification based on safety, Refrigerant oils and applications, Properties and uses of commonly used refrigerant, Greenhouse effect, Global warming, Future Refrigerants like Hydrofluoro-Olefines

Unit-II **(7 Hours)**

Heat Pump: Introduction, package heat pump with reversible cycle, decentralized heat pump, heat pump with a double bundle condenser, industrial heat pump

Ventilation: Introduction, purpose of ventilation, Natural ventilation, mechanical ventilation, tunnels ventilation, mine ventilation, Natural ventilation, and mechanical ventilation.

Air Conditioning system: Introduction, Unitary system, central air conditioning system, directs expansion system, all water system, all air system, air water system.

Unit-III **(7 Hours)**

Review of Psychrometry: Psychrometric properties, Psychrometric chart and Psychrometric processes, Psychrometric process in Air conditioning equipment: By pass factor, cooling and dehumidifying coils, Apparatus dew point (ADP), Heating coils, air washer, use of hygroscopic solution in Air Washer, adiabatic dehumidifier, water injection, stream injection, Summer Air conditioning, Winter Air conditioning, Sensible heat factor (SHF), Grand Sensible heat factor (GSHF)

Design Condition:

Choice of inside design condition- cold storage, Industrial air conditioning, comfort air conditioning, Human comfort, Outside design condition

Unit-IV: (11 Hours)

Load Calculation: Solar radiation, Heat gain through glass- Calculation of solar heat gain through ordinary glass tables-shading devices- effect of shading devices. Fabric heat gain, over all heat transfer coefficient, Periodic heat transfer through walls and roofs. Empirical methods to calculate heat transfer through walls and roofs using decrement factor and time lag method. Infiltration - stack effect, wind effect, infiltration load.

Internal heat loads, System heat gains, Break-up of ventilation and effective sensible heat factor, Cooling and heating load estimation, Psychrometric calculation for cooling, selection of air conditioning apparatus, Evaporative cooling, Building requirements and energy conservation in air conditioning buildings.

Unit-V (7 Hours)

Air Distribution: Room air distribution - types of supply air outlets, mechanism of flow through outlets, selection and location of outlets, Distribution patterns of outlets - ducts- Definition and types - materials for ducts and its specification, friction loss in ducts - grills, diffusers, registers, rectangular equivalent of circular duct. Air duct designs, duct construction, duct design procedures. Equal friction method, static regain method, velocity reduction method.

Air Conditioning Apparatus: Fans and blowers, types of fans, fan characteristic, centrifugal fans, axial fans, fan arrangements, Suction Line, Discharge Line (Hot-Gas Line), Liquid Line, location and arrangement of piping, vibration and noise in piping, basic elements of the control system

Text Books

1. Refrigeration and Air conditioning by C.P Arora, McGraw-Hill

Reference Books

2. Refrigeration and Air conditioning by stoecker& Jones. McGraw-Hill
3. Refrigeration and Air conditioning, by Manohar Prasad, New Age International (P) Ltd.Pub.
4. ASHRAE Handbook (HVAC Equipments)
5. Refrigeration and Air conditioning by R. C. Arora, PHI
6. Refrigeration and Air conditioning by Arora & Domkundwar. DhanpatRai
7. Air Conditioning System Design Manual, IInd edition, ASHRAE.

Semester – VII: Departmental Elective – IV: Specialization – Automobile Engineering

Subject Code: KAU 072	Hybrid Vehicle Propulsion	L T P : 3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand the basics of the hybrid electric vehicles and it's types.	K2
CO-2	Understand the types of drive trains used in hybrid vehicles	K2
CO-3	Understand the propulsion units used in Hybrid Vehicles and their efficiency.	K2
CO-4	Understand the requirements and devices of energy storage used in hybrid vehicles.	K2
CO-5	Understand the concept of downsizing of IC engines in case of hybrid vehicles.	K2
CO-6	Understand the principles of energy management and issues related to these strategies.	K2

UNIT I

Introduction to Hybrid Electric Vehicles: [L-4 Hours]

History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

Conventional Vehicles: [L-4 Hours]

Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.

UNIT II

Hybrid Electric Drive-trains: [L-4 Hours]

Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Electric Drive-trains: [L-4 Hours]

Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

UNIT III

Electric Propulsion unit: [L-10 Hours]

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

UNIT IV

Energy Storage: [L-5 Hours]

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy

storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.

Sizing the drive system: [L-4 Hours]

Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems

UNIT V

Energy Management Strategies: [L-8 Hours]

Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Text Books:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press , 2003.
2. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press , 2004.

Reference Books:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley , 2003.
2. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd., 2011.

Semester – VII: Departmental Elective – V: Specialization – Manufacturing and Automation

Subject Code: KME 073	Mathematical Modeling of Manufacturing Processes	L T P : 3 0 0	Credits: 3

Course Outcome: Student will be able to		Bloom Taxonomy
CO 1	Understand the fundamentals of manufacturing processes, mathematical models and their solutions.	K2
CO 2	Understand unconventional and conventional machining, their discrete-time linear and non-linear models and solutions.	K2
CO 3	Apply the principles of casting, powder metallurgy, coating and additive manufacturing.	K3
CO 4	Analyze the mechanism of heat and mass transfer in welding.	K4
CO 5	Evaluate microstructure properties and residual stress of different manufacturing processes.	K5

Unit-1: Introduction to Manufacturing processes; Materials Processing; Types and Properties of Engineered Materials; Evaluation of Properties of Manufactured Products; Statistical and data-driven modelling approach; Overview of mathematical modeling, types of mathematical models and methods to solve the same.
Physics of manufacturing processes; Solid-state deformation (Elasticity and Plasticity) and residual stresses; solid-state phase transformation and recrystallization; melting and solidification; Coupled Systems

Unit-2: Conventional machining; Orthogonal cutting; Tool geometry; chip formation; force components; heat generation; tool life; mathematical modelling approach; solution of problems; Introduction to discrete-time linear and non-linear models.
Non-conventional machining; Principal and mechanism of different processes; Parametric analysis of heat transfer, material removal, and surface finish.

Unit-3: Metal forming; Mechanics of bulk metal forming; mechanics of sheet metal forming; heat transfer and deformation;

Welding; Fusion welding; Welding-heat source modeling, temperature distribution, effect of surface-active elements, modes of metal transfer in welding; Solid-state welding; Solidification and microstructure; Residual stress and distortion.

Unit-4: Casting and powder metallurgy; Cooling and Solidification; principle of powder metallurgy;
Coating and additive manufacturing; Principle of surface and coating technology; Principle and development of additive manufacturing technologies

Unit-5: Heat treatment; Fundamentals of heat treatment; Evaluation of microstructure properties and residual stress of different manufacturing processes.

Micro/nanoscale manufacturing; Down-scaling of conventional manufacturing processes, Change of properties, Micro-to-nano manufacturing; Packaging, finishing, micro joining and nano joining, micro casting, micro forming, micromachining.

Processing of non-metallic materials; Principle of plastic processing and shaping of plastics, processing of non-metallic bio-materials; Principle of glass and ceramics processing and shaping of glass and ceramics.

Books and References

21. A Ghosh and A K Mallik: Manufacturing Science, East-West Press Pvt Ltd,2nd Ed., 2010.
22. D A Brandt, J C Warner: Metallurgy Fundamentals, Goodheart- Willcox, 2009.
23. C LakshmanaRao and Abhijit P Deshpande: Modelling of Engineering Materials, Ane Books Pvt. Ltd., New Delhi, India, 2010.
24. J. Chakrabarty: Theory of plasticity, 3rd Eds, Elsevier India,2009.
25. Norman Y Zhou: Microjoining and Nanoioining, Woodhead publishing, 2008
26. R W Messler: Principles of Welding John Wiley and Sons, 1999.
27. J T Black and Ronald A Kohser: DeGarmo's Materials & processes in Manufacturing Wiley-India, 2010.
28. V K Jain: Advanced Machining Processes, Allied Publishers, Mumbai, 2002.
29. Yi Qin: Micromanufacturing Engineering and Technology, Elsevier, 2015.
30. J Zhang and Yeon-Gil Jung: Additive Manufacturing: Materials, Processes, Quantifications and Applications, Elsevier, 2018.
31. J ADantzig and M Rappaz: Solidification, CRS press, 2009.
32. J.N. Kapur, Mathematical Models in Biology and Medicine, East-West Press Private limited.
33. Leah, Edelstein, Keshet, Mathematical Models in Biology, SIAM publications.
34. J.D. Murray, Mathematical Biology Vol. I, II, 3rd edition, Springer publications.

Related Course's / Useful Links

1. https://swayam.gov.in/nd1_noc20_hs79/preview
2. https://swayam.gov.in/nd1_noc19_me47/preview
3. https://nptel.ac.in/content/syllabus_pdf/112103273.pdf
4. https://swayam.gov.in/nd1_noc20_ma47/preview

Semester – VII: Departmental Elective – V: Specialization – Automation and Industry 4.0

Subject Code: KME 074	Machine Learning	L T P : 3 0 0	Credits: 3

Course Outcomes: Students are able to		**Bloom's Taxonomy**
CO 1	Understand machine learning concepts	K2
CO 2	Apply machine learning algorithms	K3
CO 3	Solve prediction based problems	K3
CO 4	Analyze machine learning algorithms	K4
CO 5	Solve real-world machine learning problems	K3

Unit 1: Introduction to Machine Learning **(6Hours)**

An Introduction to Machine Learning, Types of Machine Learning, and Applications of ML in Mechanical Engineering, Designing a Learning System, Issues in Machine Learning, AI vs. ML, and Essential Math for ML and AI, Common software's for ML.

Unit 2: Supervised Learning **(9Hours)**

Supervised Learning: Introduction to Supervised Learning, Linear Methods for Classification, Basis Expansions, Model Selection Procedures, Bayesian Decision Theory: Classification, Discriminant Functions, Association Rules, And Parametric Methods: Maximum Likelihood Estimation, Evaluating an Estimator: Bias and Variance, Parametric Classification, Linear Methods for Regression, Support Vector Machines.

Unit 3: Unsupervised Learning **(9Hours)**

Unsupervised Learning: Introduction to Unsupervised Learning, Association Rules Preview, Cluster Analysis, K-Means Clustering, Expectation-Maximization Algorithm, Multivariate Methods: Multivariate Data, Parameter Estimation, Estimation of Missing Values, Multivariate Normal Distribution, Multivariate Classification, Dimensionality Reduction: Principal Components Analysis, Independent Component Analysis,Multidimensional Scaling, Linear Discriminant Analysis.

Unit 4: Nonparametric estimations & Neural Networks **(9Hours)**

Nonparametric Methods, Nonparametric Density Estimation, Kernel Estimator, Nonparametric Classification, Decision Trees, Issues in Decision tree learning, Introduction to Neural Networks, The Perceptron, The Back propagation Algorithm, The Convergence analysis and universal approximation theorem for back propagation algorithm, Training Procedures Preview, Convolutional Neural Networks, Kernel Machines: Optimal Separating Hyperplane, Defining Kernels, Multiple Kernel Learning.

Unit 5: Predictive Algorithms **(7Hours)**

Bayesian Estimation, Gaussian Processes, Hidden Markov Models, Model Selection in HMM, Reinforcement Learning: Model-Based Learning, Temporal Difference Learning, Generalization, Real World ML, Choosing an Algorithm, Design and Analysis of ML Experiments.

Suggested topics for project based learning: Weather Forecasting using Machine Learning, House Price Prediction using Machine Learning, Signal Processing using Machine Learning, and Automatic robot control using machine learning.

Text Book:

1. "Introduction to Machine Learning" second edition by Ethem Alpaydın, The MIT Press Cambridge, Massachusetts London, England

Reference Book:

1. "Machine Learning" by Tom M. Mitchell, Publisher: McGraw-Hill Science/Engineering/Math

"Machine Learning for Absolute Beginner's" A complete guide to master machine learning concepts and create real world ML solutions

Semester – VII: Departmental Elective – V: Specialization – Design and Analysis

Subject Code: KME 075	Computer Graphics and Product Modeling	L T P : 3 0 0	Credits: 3

Course Outcome: Student will be able to		Bloom Taxonomy
CO 1	Understand the components of a computer graphics with object representation and to develop algorithm for graphics system components.	K2
CO 2	Understand the basic principles of 3- dimensional computer graphics and express the 3D model with illumination and shading effects.	K2
CO 3	Understand the 3D viewing pipeline and rendering to produce scale drawing of 3D objects.	K2
CO 4	Identify the customer needs in order to develop a business model for new product.	K3
CO 5	Develop strategy for designing and development of a new product	K4

Unit-1: Introduction to computer graphics – historical evolution, issues and challenges, graphics pipeline, hardware and software basics; line and circle drawing algorithms, , Object representation – boundary representation, splines- cubic, Bezier, B-spline and NURBS, space partitioning

Unit-2: Modeling transformations – matrix representation, homogeneous coordinate system, composition, 3D transformations; Illumination and shading – background, simple lighting model, shading models, intensity representation, color models, texture synthesis.

Unit-3: 3D viewing – viewing pipeline, view coordinate system, viewing transformation, projection, window-viewport transformation; Clipping and hidden surface removal – clipping in 2D, 3D, hidden surface removal; Rendering – scan conversion of line, circle, fill-area and characters, anti-aliasing; Graphics hardware and software.

Unit-4: Managing Product Development- Introduction; Business Models for New Products; Managing Product Development; Understanding Customer Needs- Identifying New Product Opportunities, Market Research for New Product Development. Introduction to Product Life Cycle Management and related softwares

Unit-5: Organizing Product Development-Product Architecture, Design for manufacturing and Prototyping; Organizing for Product Development; Developing Services and Product Service Systems; New Product Strategy- Building Markets and Creating Demand for New Products; Intellectual Property Issues in Product Development; New Product Business Plans – Strategy Consulting for New Products; Design Thinking for New Products- Designing Products for Emerging Markets; Design Thinking for New Products

Books and References

1. Samit Bhattacharya. (2015). Computer Graphics. Oxford University Press.
2. Hearn, D. & Baker, M. P. (2003). Computer Graphics with OpenGL, (3rd ed), Pearson.
3. Drew Boyd & Jacob Goldenberg (2013) Inside the Box: The Creative Method that Works for Everyone
4. Joseph V. Sinfield, Edward Calder, Bernard McConnell, and Steve Colson (2012) How to Identify New Business Models, MIT Sloan Management Review Vol. 53, No.2.

5. Chun-Che Huang (2000) Overview of Modular Product Development, Proc. National Science Council ROC(A) Vol. 24, No. 3, pp. 149-165
6. Marc H. Meyer and Arthur DeTore (1999) Product Development for Services, The Academy of Management Executive, Vol. 13, No. 3, Themes: Teams and New Product Development (Aug., 1999), pp. 64-76

Related Course's / Useful Link

1. https://swayam.gov.in/nd1_noc20_cs90/preview
2. https://nptel.ac.in/courses/106/106/106106090/
3. https://nptel.ac.in/courses/112/102/112102101/
4. https://swayam.gov.in/nd1_noc20_me12/preview
5. https://swayam.gov.in/nd1_noc20_de05/preview

Semester – VII: Departmental Elective – V: Specialization – Thermal Engineering

Subject Code: KME 076	Power Plant Engineering	L T P : 3 0 0	Credits: 3

Course Outcome: The student will be able to		Bloom Taxonomy
CO-1	Understand the different sources of power generation and their impact on environment.	K2
CO-2	Understand the elements of power generation using fossil fuels.	K2
CO-3	Understand the elements of power generation using nuclear and renewable energy sources.	K2
CO-4	Understand the concepts of electrical systems used in power plants	K2
CO-4	Apply the basic concepts of thermodynamics to measure the performance of different power plants.	K3
CO-5	Determine the performance of power plants based on load variations.	K3

UNIT-I: Introduction

Power and energy, sources of energy, review of thermodynamic cycles related to power plants, fuels and combustion calculations. Load estimation, load curves, various terms and factors involved in power plant calculations. Effect of variable load on power plant operation, Selection of power plant units. Power plant economics and selection Effect of plant type on costs, rates, fixed elements, energy elements, customer elements and investor's profit; depreciation and replacement, theory of rates. Economics of plant selection, other considerations in plant selection.

UNIT-II: Steam power plant

General layout of steam power plant, Power plant boilers including critical and super critical boilers. Fluidized bed boilers, boilers mountings and accessories, Different systems such as coal handling system, pulverisers and coal burners, combustion system, draft, ash handling system, Dust collection system, Feed water treatment and condenser and cooling towers and cooling ponds, Turbine auxiliary systems such as governing, feed heating, reheating, flange heating and gland leakage. Operation and maintenance of steam power plant, heat balance and efficiency, Site selection of a steam power plant.

UNIT-III: Diesel power plant

General layout, Components of Diesel power plant, Performance of diesel power plant, fuel system, Lubrication system, air intake and admission system, supercharging system, exhaust system, diesel plant operation and efficiency, heat balance, Site selection of diesel power plant, Comparative study of diesel power plant with steam power plant.

Gas turbine power plant: Layout of gas turbine power plant, Elements of gas turbine power plants, Gas turbine fuels, cogeneration, auxiliary systems such as fuel, controls and lubrication, operation and maintenance, combined cycle power plants, Site selection of gas turbine power plant, Integrated Gas fire based Combined Cycle (IGCC) systems.

UNIT-IV: Nuclear power plant

Layout and subsystems of nuclear power plants, Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANDU Reactor, Pressurized Heavy Water Reactor (PHWR), Fast Breeder Reactors (FBR), gas cooled and liquid metal cooled reactors, safety measures for nuclear power plants. Hydroelectric

and Non-Conventional Power Plant: Hydroelectric power plants, classification, typical layout and components, principles of wind, tidal, solar PV and solar thermal, geothermal, biogas and fuel cell power systems.

UNIT-V: Electrical system

Generators and generator cooling, transformers and their cooling, bus bar, etc. Energy Saving and Control: Energy, economic and environmental issues, power tariffs, load distribution parameters, load curve, capital and operating cost of different power plants, pollution control technologies including waste disposal options for coal and nuclear plants.

Books and References:

1. Power Plant Engineering, by F.T. Morse, Affiliated East-West Press Pvt. Ltd.
2. Power Plant Engineering by Hedge, Pearson India.
3. Power Plant Technology, by Wakil, McGraw Hill.
4. Power Plant Engineering by P.K. Nag, Tata McGraw Hill.
5. Steam & Gas Turbines & Power Plant Engineering by R.Yadav, Central Pub.House.
6. Power Plant Engineering by Gupta, PHI India.
7. El Wakil M.M., Power Plant Technology, Tata McGraw Hill, 2010.
8. Power Plant Engineering. Mahesh Verma, Metropolitan Book Company Pvt. Ltd.

Semester – VII: Departmental Elective – V: Specialization – Automobile Engineering

Subject Code: KAU 073	Vehicle Body Engineering & safety	L T P : 3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand the classification of the vehicles on the basis of body.	K2
CO-2	Understand the importance of material selection in designing automotive bodies.	K2
CO-3	Understand the concepts of aerodynamics used in designing automobiles.	K2
CO-4	Understand the importance of interior and exterior ergonomics while designing the vehicle.	K2
CO-5	Identify various sources of noise and methods of noise separation and various safety aspects in a given vehicle.	K2
CO-6	Calculate various aerodynamic forces and moments acting on vehicle, load distribution in vehicle body and stability of vehicle.	K3

UNIT-I:

Classification of Coachwork: [L-9 Hours]

Styling forms, coach and bus body style, layout of cars, buses and coach with different seating and loading capacity, types of commercial vehicles, vans and pickups, etc. Terms used in body building construction, angle of approach, Angle of departure, ground clearance, Cross bearers, floor longitudes, posts, seat rail, waist rail, cant rail, Roof stick, Roof longitude, Rub rail, skirt rail, truss panel, wheel arch structure, wheel arch, post diagonals, gussets.

UNIT-II:

Vehicle Body Materials: [L-9 Hours]

Aluminum alloys, Steel, alloy steels, plastics, Metal matrix composites, structural timbers - properties, glass reinforced plastics and high strength composites, thermoplastics, ABS and styrenes, load bearing plastics, semi rigid PUR foams and sandwich panel construction. Paints adhesives and their properties, corrosion and their prevention.

UNIT-II:

Aerodynamics: [L-5 Hours]

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.

Load Distribution: [L-5 Hours]

Type of body structures, Vehicle body stress analysis, vehicle weight distribution, Calculation of loading for static loading, symmetrical, longitudinal loads, side loads, stress analysis of bus body structure under bending and torsion.

UNIT-IV:

Interior Ergonomics: [L-4 Hours]

Introduction, Seating dimensions, Interior ergonomics, ergonomics system design, seat comfort, 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.

Vehicle Stability: [L-4 Hours]

Introduction, Longitudinal, lateral stability, vehicle on a curvilinear path, critical speed for toppling and skidding.Effect of operating factors on lateral stability, steering geometry and stabilization of steerable wheels, mass distribution and engine location on stability.

UNIT-V:

Noise and Vibration: [L-5 Hours]

Noise characteristics, Sources of noise, noise level measurement techniques, Body structural vibrations, chassis bearing vibration, designing against fatigue, methods of noise suppression.

Impact protection: [L-5 Hours]

Basics, physics of impact between deformable bodies, design for crash worthiness, occupant and cargo restraint, passive restraint systems, side impact analysis, bumper system, energy absorbent foams, laws of mechanisms applied to safety**.**

Books &Reference:

1. Bosch, “Automotive Handbook”, 8th Edition, SAE publication, 2011.
2. Powloski J., “Vehicle Body Engineering”, Business books limited, London, 1969.
3. Ronald K. Jurgen, “Automotive Electronics Handbook”, Second Edition, McGraw-Hill Inc., 1999.
4. Vehicle body engineering Giles J Pawlowsky Business books limited 1989
5. Vehicle body layout and analysis John Fenton Mechanical Engg. Publication ltd, London. 1990
6. Vehicle Safety 2002 Cornwell press Town bridge, UK ISBN 1356 – 1448
7. Aerodynamics of Road Vehicles W.H. Hucho Butter worth’s 1987 4th Edition