LINGAYA'S VIDYAPEETH

SCHEME OF STUDIES

SESSION: 2021-22

School: Engineering and Technology	**Batch: 2021-25**
Department: Mechanical Engineering	**Year: 1st Year**
Course: B.Tech (Mechanical)	**Semester: I**

SN	Category	Course Code	Course Name	Periods			Credits	Evaluation Scheme					Subject Total Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	
1	**BSC**	BS-107	Mathematics-I	3	1	0	4	15	25	60			100
2	**BSC**	BS-109	Physics	3	1	0	4	15	25	60			100
3	**ESC**	EC-101	Basic Electrical and Electronics Engineering	3	0	0	3	15	25	60			100
4	**ESC**	CS-101	Programming for problem solving	3	0	0	3	15	25	60			100
5	**HSMC**	HSS-101	Effective Technical Communication	3	0	0	3	15	25	60			100
6	**PCC**	ME-151	Workshop Practice	0	0	4	2				60	40	100
7	**BSC**	BS-159	Physics lab	0	0	2	1				60	40	100
8	**ESC**	EC-151	Basic Electrical and electronics Engineering lab	0	0	2	1				60	40	100
9	**HSMC**	HSS-151	English Communication Lab.	0	0	2	1						100
10	**ESC**	CS-151	Programming for problem solving using C lab	0	0	2	1				60	40	100
			Total Credits				**23**						

School: Engineering and Technology								Batch: 2021-25					
Department: Mechanical Engineering								Year: 1st Year					
Course: B.Tech (Mechanical)								Semester: II					
SN	Cate-gory	Course Code	Course Name	Periods			Credits	Evaluation Scheme					Subject Total Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	
1	BSC	BS-108	Mathematics-II	3	1	0	4	15	25	60			100
2	BSC	BS-110	Environment Science and Chemistry	2	0	0	2	15	25	60			100
3	PCC	ME-102	Engineering Mechanics	3	0	0	3	15	25	60			100
4	PCC	ME-104	Material science	3	0	0	3	15	25	60			100
5	PCC	ME-106	Thermodynamics	3	0	0	3	15	25	60			100
6	HSMC	PEP-102	Universal Human Values	1	0	2	2						100
7	PCC	ME-152	Engineering graphics Lab	0	0	4	2				60	40	100
8	BSC	BS-160	Environment science and chemistry lab	0	0	2	1				60	40	100
9	PCC	ME-154	Material science lab	0	0	2	1				60	40	100
			Total Credits				21						

School: Engineering and Technology	Batch: 2021-25
Department: Mechanical Engineering	Year: 2nd Year
Course: B.Tech (Mechanical)	Semester: III

SN	Cate-gory	Course Code	Course Name	Periods			Credits	Evaluation Scheme					Subject Total Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	
1	**BSC**	BS-201	Numerical and Statistical Methods	3	1	0	4	15	25	60			100
2	**PCC**	ME-203	Thermal Engineering	3	1	0	4	15	25	60			100
3	**ESC**	CS-201	Data Structures and Algorithms	3	1	0	4	15	25	60			100
4	**ESC**	CS-205	Python Programming	3	0	0	3	15	25	60			100
5	**PCC**	ME-253	Thermal Engineering lab	0	0	2	1				60	40	100
6	**PCC**	ME-255	Computer Aided Machine Drawing	0	0	4	2				60	40	100
7	**ESC**	CS-251	Data Structures and Algorithms Lab	0	0	2	1				60	40	100
8	**ESC**	CS-255	Python Programming Lab	0	0	2	1				60	40	100
9	**HSMC**	PEP-201	Exploring Self	1	0	2	2						100
			Total Credits				**22**						

School: Engineering and Technology	Batch:2021-25
Department: Mechanical Engineering	Year: 2nd Year
Course: B.Tech (Mechanical)	Semester: IV

SN	Cate-gory	Course Code	Course Name	Periods			Credits	Evaluation Scheme					Subject Total Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	
1	PCC	ME-202	Fluid Mechanics	3	1	0	4	15	25	60			100
2	PCC	ME-204	Strength of materials	3	1	0	4	15	25	60			100
3	PCC	ME-206	Computer Aided Measurement and Inspection	3	0	0	3	15	25	60			100
4	PCC	ME-208	Manufacturing sciences	3	0	0	3	15	25	60			100
5	PCC	EC-212	Modern electrical and electronics technologies	3	0	0	3	15	25	60			100
6	PCC	ME-252	Fluid Mechanics Lab	0	0	2	1				60	40	100
7	PCC	ME-254	Strength of materials lab	0	0	2	1				60	40	100
9	MC	MC-202	Indian Constitution	0	0	0	0						100
			Total Credits				**19**						

School: Engineering and Technology								Batch:2021-25					
Department: Mechanical Engineering								Year: 3rd Year					
Course: B.Tech (Mechanical)								Semester: V					
SN	Cate-gory	Course Code	Course Name	Periods			Credits	Evaluation Scheme					Subject Total Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	
1	PCC	ME-301	Mechanics of material	3	1	0	4	15	25	60			100
2	PCC	ME-303	Manufacturing technology	3	0	0	3	15	25	60			100
3	PCC	ME-305	Heat Transfer	3	1	0	4	15	25	60			100
4	PCC	ME-307	Management science and productivity	3	0	0	3	15	25	60			100
5	PCC	ME-309	Fluid machinery	3	1	0	4	15	25	60			100
6	PEC	ME-321/ MEDP-321/ MEEV-321	Program Elective-I Sustainable energy Engineering/ Fundamentals of 3 D printing/ Fundamentals of Electricand Hybrid Vehicles	3	0	0	3	15	25	60			100
8	PCC	ME-353	Manufacturing Technology Lab	0	0	2	1				60	40	100
9	PCC	ME-355	Heat Transfer Lab	0	0	2	1				60	40	100
	PCC	ME-359	Fluid machinery lab	0	0	2	1				60	40	100
10	PROJ	ME-357	Summer Training	0	0	2	1						100
11	HSMC	PEP-301	Leadership and Management Skills	1	0	2	2						100
			Total Credits				26						

School: Engineering and Technology								Batch: 2021-25					
Department: Mechanical Engineering								Year: 3rd Year					
Course: B.Tech (Mechanical)								Semester: VI					
SN	Cate-gory	Course Code	Course Name	Periods			Credits	Evaluation Scheme					Subject Total Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	
1	PCC	ME-302	CAD/CAM/CIM	3	0	0	3	15	25	60			100
2	PCC	ME-304	Theory of machine	4	0	0	3	15	25	60			100
3	PCC	ME-306	Mechatronics and automation	3	0	0	3	15	25	60			100
4	PCC	ME-308	Machine Design	3	1	0	4	15	25	60			100
5	PEC	ME-322/ MEDP-322/ MEEV-322C	Program Elective-II Power plant engineering / Additive manufacturing/ Electric vehicle technology	3	0	0	3	15	25	60			100
6	PCC	ME-352	CAD/CAM lab	0	0	2	1				60	40	100
7	PCC	ME-354	Theory of machine lab	0	0	2	1				60	40	
8	PCC	ME-356	Mechatronics and automation lab	0	0	2	1				60	40	100
9	PROJ	ME-358	Mini project	0	0	4	2						100
10	MC	MC-302	Essence of Indian Traditional Knowledge	0	0	0	0						100
			Total Credits				22						

School: Engineering and Technology								Batch: 2021-25					
Department: Mechanical Engineering								Year: 4th Year					
Course: B.Tech (Mechanical)								Semester: VII					
SN	Cate-gory	Course Code	Course Name	Periods			Credits	Evaluation Scheme					Subject Total Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	
1	HSMC	MG-405	Operations Research	3	0	0	3	15	25	60			100
2	PEC	ME-421/ MEDP-421/ MEEV-421	Program Elective-III Mechanical vibration/3 D printing process and application/ Smart sensors	3	0	0	3	15	25	60			100
3	PEC	ME-423/ MEDP-423/ MEEV-423/	Program Elective-IV Automotive engineering/ Product design and development/ EV battery and charging system	3	0	0	3	15	25	60			100
4	OE	ME-431A/ ME 431B	Open Elective-I	3	0	0	3	15	25	60			100
5	PROJ	ME-451	Seminar and General Proficiency	0	0	2	1						100
6	PROJ	ME-453	Summer Internship	0	0	4	2						100
7	PROJ	ME-455	Project Work-I	0	0	6	4						100
8	HSMC	PEP-401	Professional Skills	1	0	2	2						100
			Total Credit				21						

School: Engineering and Technology	Batch: 2021-25
Department: Mechanical Engineering	Year: 4th Year
Course: B.Tech (Mechanical)	Semester: VIII

SN	Cate-gory	Course Code	Course Name	Periods			Credits	Evaluation Scheme					Subject Total Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	
1	**HSMC**	MG-408	Economic Life Cycle concepts	3	0	0	3	15	25	60			100
2	**PEC**	ME-422/ MEDP-422/ MEEV-422	Program Elective-V Industrial Automation/ Metal additive manufacturing / Hybrid electric vehicle technology	3	0	0	3	15	25	60			100
3	**PEC**	ME-424/ MEDP-424/ MEEV-424	Program Elective-VI Unconventional machining/ Unconventional machining process/ Electrical and autonomous road vehicle	3	0	0	3	15	25	60			100
4	**OE**	ME-432A/ ME-432B	Open Elective-II	3	0	0	3	15	25	60			100
5	**PROJ**	ME-452	Project work-II	0	0	20	10						100
			Total Credit				**22**						

Abbreviations:

PCC: Programme Core Courses
PEC: Programme Elective Courses
PROJ: Project
PDP: Personality Development Programme
L: Lecture
T: Tutorial
P: Practical
BSC: Basic Sciences
HSS: Humanities and Social Sciences
ESC: Engineering Sciences

ABQ: Assignment Based Quiz
MSE: Mid Semester Examination
ESE: End Semester Examination
IP: Internal Practical
EXP: External Practical

List of Open Elective-I

SN	Cate-gory	Course Code	Course Name	Periods			Credits	Evaluation Scheme					Subjec t Total Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	
1	**OE**	ME-431A	Refrigeration and air conditioning	3	0	0	3	15	25	60			100
2	**OE**	ME-431B	Optimization techniques	3	0	0	3	15	25	60			100

List of Open Elective-II

SN	Cate-gory	Course Code	Course Name	Periods			Credits	Evaluation Scheme					Subject Total Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	
1	**OE**	ME-432A	Industrial robot	3	0	0	3	15	25	60			100
2	**OE**	ME-432B	Automotive maintenance service	3	0	0	3	15	25	60			100

List of elective

SEM	Mechanical engineering	3D - printing	Electric vehicles
Elective –I Vth	Sustainable energy Engineering ME 321	Fundamentals of 3 D printing MEDP-321	Fundamentals of Electricand Hybrid Vehicles MEEV-321
Elective –II VIth	Power plant engineering ME 322	Additive manufacturing MEDP-322	Electric vehicle technology MEEV-322
Elective –III VIIth	Mechanical vibration ME 421	3 D printing process and application MEDP-421	Smart sensors MEEV-421
Elective –IV VIIth	Automotive engineering ME 423	Product design and development MEDP-423	EV battery and charging system MEEV-423
Elective –V VIIIth	Industrial Automation ME 422	Metal additive manufacturing MEDP- 422	Hybrid electric vehicle technology MEEV-422
Elective –VI VIIIth	Unconventional machining process ME 424	Unconventional machining process ME 424	Electrical and autonomous road vehicle MEEV-424

List of Program Electives (Mechanical Engineering)

SN	Category	Course Code	Course Name	Periods			Credits	Evaluation Scheme					SubjectTotal Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	
1	**PEC**	ME-321	Sustainable energy Engineering	3	0	0	3	15	25	60			100
2	**PEC**	ME-322	Power plant engineering	3	0	0	3	15	25	60			100
3	**PEC**	ME-421	Mechanical vibration	3	0	0	3	15	25	60			100
4	**PEC**	ME-423	automotive engineering	3	0	0	3	15	25	60			100
5	**PEC**	ME-422	Industrial Automation	3	0	0	3	15	25	60			100
6	**PEC**	ME-424	unconventional machining process	3	0	0	3	15	25	60			100

List of Program Electives (3D Printing)

SN	Category	Course Code	Course Name	Periods			Credits	Evaluation Scheme					SubjectTotal Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	
1	**PEC**	MEDP-321	Fundamentals of 3 D printing	3	0	0	3	15	25	60			100
2	**PEC**	MEDP-322	Additive manufacturing	3	0	0	3	15	25	60			100
3	**PEC**	MEDP-421	3 D printing process and application	3	0	0	3	15	25	60			100
4	**PEC**	MEDP-423	Product design and development	3	0	0	3	15	25	60			100
5	**PEC**	MEDP- 422	Metal additive manufacturing	3	0	0	3	15	25	60			100
6	**PEC**	ME 424	Unconventional machining process	3	0	0	3	15	25	60			100

List of Program Electives (Electric Vehicle Technology)

SN	Category	Course Code	Course Name	Periods			Credits	Evaluation Scheme					SubjectTotal Marks
								Theory			Practical		
				L	T	P		ABQ	MSE	ESE	IP	EXP	

1	**PEC**	MEEV-321	Fundamentals of Electric & Hybrid Vehicles	3	0	0	3	15	25	60			100
2	**PEC**	MEEV-322	Electric vehicle technology	3	0	0	3	15	25	60			100
3	**PEC**	MEEV-421	Smart sensors	3	0	0	3	15	25	60			100
4	**PEC**	MEEV-423	EV battery and charging system	3	0	0	3	15	25	60			100
5	**PEC**	MEEV-422	Hybrid electric vehicle technology	3	0	0	3	15	25	60			100
6	**PEC**	MEEV-424	Electrical and autonmous road vehicle	3	0	0	3	15	25	60			100

SYLLABUS

(III SEMESTER)

Course code	Course title	L	T	P	Credits
BSC-201	**NUMERICAL and STATISTICAL METHODS**	3	1	0	4

Course objective:

1. Derive appropriate numerical methods to solve algebraic and transcendental equations
2. Develop appropriate numerical methods to approximate a function
3. The main objective of this course is to understand and implement various concepts of numerical analysis and statistics to solve real life problems.
4. Analysis of Statistical Data: Frequency distribution; Frequency curve and histogram;
5. Measure of central tendency and dispersion

UNIT 1: ERRORS AND APPROXIMATIONS, SOLUTION OF NONLINEAR - EQUATIONS : Introduction to numbers and their accuracy; absolute, relative and percentage errors. Bisection method; Regular falsi method; secant method; fixed point iteration method; Newton- Raphson method; convergence criteria of methods. **(Hours-8)**

UNIT 2: SOLUTION OF SIMULTANEOUS LINEAR EQUATIONS: Gauss elimination method; Gauss-Jordan method; UV factorization method; Jacobi's iteration method; Gauss-Seidal iteration method. **(Hours-8)**

UNIT 3: INTERPOLATION AND CURVE FITTING: Introduction to interpolation; Newton's forward and backward interpolation formulae; Gauss's forward and backward interpolation formulae; Stirling formula; Lagrange interpolation; Newton's divided difference formula; Principle of least squares; curve fitting. **(Hours-8)**

UNIT 4: NUMERICAL DIFFERENTIATION AND INTEGRATION: Numerical differentiation formulae: differentiation by using forward interpolation formula; backward interpolation formula; Stirling formula; Newton-Cotes formula for numerical integration: Trapezoidal rule; Simpson's rules; Boole's rule and Weddle's rule; Romberg' method. **(Hours-8)**

UNIT 5: Simple Correlation and Regression Analysis

Correlation Analysis: Meaning and types of Correlation; Pearson's coefficient of correlation: computation and properties (proofs not required). Probable and standard errors; Rank correlation. Regression Analysis: Principle of least squares and regression lines; Regression equations and estimation; Properties of regression coefficients; Relationships between Correlation and Regression coefficients; Standard Error of Estimate**.** **(Hours-8)**

TEXT BOOK

1.Grewal, B. S., "Numerical methods in Engineering and Science",9th Edition, 2010, Khanna publishers. And Higher Engineering Mathematics

REFERENCE BOOK

1. Jain, R.K. and Iyengar, S.R.K., "Numerical Methods for Scientific and Engg. Computations" ,5th Edition,2007, New Age International publishers.
2. Sastry, S.S.," "Introductory Methods of Numerical Analysis",3rd Edition,1999, Prentice Hall ofIndia.
3. Numerical Methods for Engineers, Steven C. Chapra, Raymond P. Canale Tata McGraw Hill, 2010

Course outcomes:
1. The mathematical tools needed in evaluating multiple integrals and their usage. 2. The effective mathematical tools for the solutions of differential equations that model physical processes. 3. To acquaint the students with the various concepts and tools of applied mathematics which will be very basic and the very soul and guide of various engineering subject. 4. Students will use mathematics concepts in real world situations. 5. Students will simplify and perform operations with nonlinear expressions

NUMERICAL and STATISTICAL METHODS BSC - 201	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2	1	2		1	2	2	1		1	3	1		
	CO2	2	2		1		2		1		1	3	2		
	CO3	2		1			2	1		2	1	3	1		
	CO4	1						1							
	CO5									1					

Course code	Course title	L	T	P	Credits
ME-203	Thermal Engineering	3	1	0	4

Course objective:
1. This course introduces the student to the fundamental laws of thermodynamics, the interaction between Energy and matter, the quantitative and qualitative aspects of energy and its transformations, the properties of the working substance and their relationship. 2. Evaluate the properties of pure substances and mixtures. 3. Understand and analyze power and refrigeration cycles. 4. To integrate the concepts, laws and methodologies from the first course in thermodynamics into analysis of cyclic processes. 5. To apply the thermodynamic concepts into various thermal application like IC engines.

UNIT-1: GAS AND STEAM POWER CYCLES

Air Standard Cycles – Otto, Diesel, Dual, Brayton – Cycle Analysis, Performance and Comparison– Rankine, reheat and regenerative cycle. **(Hours-8)**

UNIT-2: RECIPROCATING AIR COMPRESSOR

Classification and comparison, working principle, work of compression – with and without clearance, Volumetric efficiency, Isothermal efficiency and Isentropic efficiency. Multistage air compressor with Intercooling. Working principle and comparison of Rotary compressors with reciprocating air compressors. **(Hours-8)**

UNIT-3: INTERNAL COMBUSTION ENGINES AND COMBUSTION

IC engine – Classification, working, components and their functions. Ideal and actual : Valve and port timing diagrams, p-v diagrams- two stroke & four stroke, and SI & CI engines – comparison. Geometric, operating, and performance comparison of SI and CI engines. Desirable properties and qualities of fuels. Air-fuel ratio calculation – lean and rich mixtures. Combustion in SI & CI Engines – Knocking – phenomena and control. **(Hours-8)**

UNIT-4: INTERNAL COMBUSTION ENGINE PERFORMANCE AND SYSTEMS

Performance parameters and calculations. Morse and Heat Balance tests. Multipoint Fuel Injection system and Common Rail Direct lnjection systems. Ignition systems – Magneto, Battery and Electronic. Lubrication and Cooling systems. Concepts of Supercharging and Turbocharging – Emission Norms. **(Hours-8)**

UNIT-5: GAS TURBINES

Gas turbine cycle analysis – open and closed cycle. Performance and its improvement – Regenerative, Intercooled, Reheated cycles and their combinations. Materials for Turbines. **(Hours-8)**

TEXT BOOKS:

- Kothandaraman.C.P., Domkundwar. S,Domkundwar. A.V., "A course in thermal Engineering", Fifth Edition, "Dhanpat Rai & sons , 2016
- Rajput. R. K., "Thermal Engineering" S.Chand Publishers

REFERENCES:

- Arora.C.P, "Refrigeration and Air Conditioning ," Tata McGraw-Hill Publishers 2008
- Ganesan V.." Internal Combustion Engines" , Third Edition, Tata Mcgraw-Hill 2012
- Ramalingam. K.K., "Thermal Engineering", SCITECH Publications (India) Pvt. Ltd., 2009.
- Rudramoorthy, R, "Thermal Engineering ",Tata McGraw-Hill, New Delhi,2003
- Sarkar, B.K,"Thermal Engineering" Tata McGraw-Hill Publishers, 2007

Course outcomes:
CO1. To apply thermodynamic concepts to different air standard cycles and solve problems.
CO2. To solve problems in single stage and multistage air compressors
CO3. Explain the functioning and features of IC engines, components and auxiliaries.
CO4. Students can calculate performance parameters of IC Engines.
CO5. Explain the flow in Gas turbines and solve problems.

Thermal Engineering ME-203	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2	1	1		1					2	1	1		
	CO2	2	2	1			2	1		1	2		1		
	CO3	3	2				1				2		2		
	CO4	1						2							1
	CO5				1							1			2

CS.201	DATA STRUCTURES AND ALGORITHMS	L. T. P	Cr
		3 1 0	4

Course objective:
To relay the theoretical and practical fundamental knowledge of most commonly used algorithms

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UNIT l

INTRODUCTION TO DATA STRUCTURES AND RUNNING TIME: Definition of data structures and abstract data types: linear vs. non-linear data structure; primitive vs. non-primitive data structure; static and dynamic implementations; arrays, 1.2- dimensional arrays insertion & deletion in 1-D array; examples and real life applications. Time complexity; Big Oh notation; running times; gest case, worst ease, average case; factors depends on running time; introduction to recursion.

UNIT ll

STACKS AND QUEUES: Stacks; Definition, array based, implementation of stacks. Examples; infix postfix prefix representation; conversions, applications; definition of queues, circular queues; array based implementation of queues.

UNIT lll

LINKED LISTS: Lists; different type of linked lists; implementation of singly linked list linked list implementation of stacks and queues; implementation of circular linked list; implementation of doubly linked list, applications.

UNIT IV

TREES AND GRAPHS: Definition of trees and binary trees; properties of binary trees and implementation; binary traversal pre-order, post order, in-order traversal; binary search trees: searching, insertion & deletion. Definition of undirected and directed graphs: array based implementation of graphs; adjacency matrix; path matrix implementation: linked list representation of graphs; graph traversal: breadth first traversal, depth first traversal; implementations and applications.

UNIT V

SORTING AND SEARCHING ALGORITHMS: Introducing, selection, insertions, bubble sort, efficiency of above algorithms; merge sort, merging of sorted arrays and algorithms: quick sort algorithm analysis, heap sort, searching algorithms: straight sequential search, binary search (recursive & non-recursive algorithms)

TEXT BOOK

1. Langsam, Augentem M.J and Tenenbaum A.M., Data Structures using C & C++1, Prentice Hall of India, 2009.
2. R.S.Salariya, Data Structure and Algorithm, Khanna Publications.

REFERENCE BOOKS

1. Aho A.V., Hopcroft J.E and Ullman T.D., - Data Structures and Algoritmsl, Original Edition, Addison-Wesley, Low Priced Edition, 1983
2. Horowitz Ellis and S ahni S artaj, -Fundamentals of Data Structuresl, AddisonWesley Pub, 1984.
3. Horowitz, S ahni and Rajasekaran, -Fundamentals of Computer Algorithmsl 2007.
4. Kruse Robert, -Data Structures and Program Design in CI, Prentice Hall of India, 1994
5. Lipschetz Jr. Seymour, -Theory & Problems of Data Structuresl, S chaum's Outline, Tata Mcgraw Hill
6. Weiss Mark Allen, - Data Structures and Algorithms Analysis in CI, Pearson Education, 2000
7. Corm en T H . et al., - Introduction to Alogorithmsl, 2nd Edition, Prentice Hall of India, 2002
8. Dasgupta Sanjay, Christos P. and Vazirani Umesh, -Algorithmsl, Tata Mcgraw Hill, 2008

Course outcomes:

CO1: Understand the concept of Dynamic memory management, data types, algorithms, big notation.
CO2: Understand basic data structures such as arrays, linked lists, stacks and queues.
CO3: Describe the hash function and concepts of collision and its resolution methods.
CO4: Solve problem involving graphs, trees and heaps
CO5: Apply Algorithm for solving problems like sorting, searching, insertion and deletion of data.

DATA STRUCTURES AND ALGORTTHMS CS.201	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2	1	1		1					2	1	1		
	CO2	2	2	1			2	1		1	2		1		
	CO3	3	2				1				2		2		
	CO4	1						2							1
	CO5				1							1			2

CS.205	PYTHON PROGRAMMING	L. T. P	Cr
		3 0 0	3

Course objective:
To build programming logic and thereby developing skills in problem solving using Python programming language; To be able to do testing and debugging of code written in Python Emphasize the concepts and constructs rather than on language features.

UNIT I

INTRODUCTION TO PYTHON: History, Features & Benefits of Python, Structure of a Python Program, Identifiers and Keywords, Concept of Variable, Memory Allocation for Variable, Data Types in Python, Conversion Functions, Operators (Arithmetic Operator, Relational, Logical or Boolean Operator, Assignment, Bitwise Operator, Membership Operator) Input and Output Function, Control Statements (Looping- while Loop, for Loop, Loop Control, Conditional Statement-if… else), Difference between Break, continue and pass.

UNIT II

DATA STRUCTURES & FUNCTION: String, Lists, Tuples, Sets, Dictionary Data Structure, Built-in Library Function, Method and Operation on these Data Structure. Defining Function, Type of Function Arguments (Required Arguments, Keyword Arguments, Default Arguments, Variable-Length Arguments), Pass by Reference Vs Pass by Value. Concept of Recursion, Lambda Functions, Scope of a Variable, Global Vs Local Variable, Python Modules & Packages, Import Statement, dir(), global(), locals() and reload() functions.

UNIT III

PYTHON ONJECT ORIENTED PROGRAMMING: Introduction to Object Oriented Programming, Concept of Abstraction, Encapsulation, Class, Object and Instances. Creating Classes, _init_() Method, Creating Instance Object, Class Attributes, Access Specifiers in Python, Instance Method Vs Class Method. Inheritance & Polymorphism, Overriding ad Overloading Methods, Overloading Operators, Programming Using OOP Support.

UNIT IV

PYTHON FILE HANDLING, EXCEPTION HANDLING & CONCURRENCY: Opening & Closing Files, File Access Modes, File Object Attributes, Reading and Writing Files, Manipulating File Pointer using seek and tell. Programming using File Operations. Exception Handling in Python.

UNIT V

PYTHON MYSQL: Mysql/Oracle Database Connection using Python. Creating Database Tables, SELECT, INSERT, UPDATE, And DELETE Operation, Performing Commit, Rollback Operation.

TEXT BOOKS

Joh V Guttag, "Introduction to Computation and Programming Using Python", Prentice Hall of India

REFERENCE BOOKS

1. T. Budd, Exploring Python, TMH, 1st Ed, 2011
2. Python Tutorial/Documentation www.pthon.or2010
3. Allen Downey, Jeffrey Elkner, Chris Meyers, How to think like a computer scientist learning with Python, Freelyavailableonline.2012
4. http://docs.python.org/3/tutorial/index.html
5. http://interactivepython.org/courselib/static/pythonds
6. http://www.ibiblio.org/g2swap/byteofpython/read/

Course outcomes:
CO1: Define and demonstrate the use of built-in data structures "list" and "dictionary". CO2: Design and implement a program to solve a real world problem. CO3: Solve exception handling problem and files. CO4: Make database connectivity in python programming language

PYTHON PROGRAMMING CS.205	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2	1	1		1			2		2	1	1		
	CO2	2	2	1			2	1	1	1	2		1		
	CO3		2		2		1		1		2		2		
	CO4	1						2							1

Course code	Course title	L	T	P	Credits
ME-253	Thermal Engineering Lab	0	0	2	1

Course objective:
1. To provide hands on experience in operating various types of internal combustion engines and understand their functioning and performance.

LIST OF EXPERIMENTS **Number of hours -13**

1. To study low pressure boilers with their accessories and mountings
2. To study high pressure boilers with their accessories and mountings
3. To prepare heat balance sheet for a given boiler
4. To study impulse and reaction steam turbines
5. To find out dryness fraction of steam by throttling calorimeter
6. To calculate power output and efficiency of a steam turbine

7. To study and determine the condenser efficiency
8. To study and determine the volumetric efficiency of a reciprocating air compressor
9. To study cooling tower and determine its efficiency
10. To determine calorific value of a sample of fuel using bomb calorimeter
11. To determine composition of flue gases by orsat Apparatus

Note- The initial lab period is of introduction part for the concerned lab. The second period will be of conduct on model experimentation.

Course outcomes:
CO1. To apply the knowledge of mathematics, science and engineering fundamentals to model the energy conversion phenomenon. CO2. To identify and formulate power production based on the fundamentals laws of thermal engineering CO3.Students can able to understand the basic concepts of Gas power cycles CO4.Students can able to compare various steam Turbine & Steam Nozzle CO5. Students can able to Examine Single Acting &Double Acting Compressor

Thermal Engineering lab ME-253	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	1				1					2	1	1		1
	CO2	2		1	1		2	1		1			1		
	CO3	3	2				1				2		2		
	CO4	1													1
	CO5				1		1					1			

Course code	**Course name**	**L**	**T**	**P**	**Cr**
ME-255	Computer aided machine drawing	0	0	4	2

Course objective:
1. Comprehending material flow and scheduling in manufacturing processes by: Extracting product information for bills of material. Understanding material flow for part production. 2. To familiarize with the standard conventions for different materials and machine parts in working drawings. 3. To gain knowledge of conventional representation of various machining and mechanical details 4. To make part drawings including sectional views for various machine elements.

5. To gain knowledge of threads, bolts, nuts, stud bolts, tap bolts, set screws, Keys, cottered joints and knuckle joint.

UNIT-1:

Introduction: Review of the graphic interface of the software. Review of basic sketching commands and navigational commands. Starting a new drawing sheet. Sheet sizes. Naming a drawing, Drawing units, grid and snap. Conversion of pictorial views into orthographic projections of simple machine parts (with and without section). Hidden line conventions. Precedence of lines. **(Hours-8)**

UNIT-2:

Keys: Parallel key, Taper key, Feather key, Gib-head key and Woodruff key.
Joints: Cotter joint (socket and spigot), knuckle joint (pin joint) for two rods.
Couplings: Split Muff coupling, Protected type flanged coupling, pin (bush) type flexible coupling, and universal coupling (Hooks' Joint). **(Hours-8)**

UNIT-3:

Limits, Fits and Tolerances: Introduction, Fundamental tolerances, Deviations, Methods of placing limit dimensions, machining symbols, types of fits with symbols and applications, geometrical tolerances on drawings. Standards followed in the industry. **(Hours-8)**

UNIT-4: Assembly Drawings: (Part drawings shall be given)
1. Plummer block (Pedestal Bearing)
2. Lever Safety Valve
3. I.C. Engine connecting rod
4. Screw jack (Bottle type)
5. Tailstock of lathe
6. Machine vice
7. Tool head of the shaper **Hours-8)**

UNIT-5: Project Work

Prepare assembly drawing of mechanical components with codes, standards and symbols using AutoCAD.

B. List of Major Equipment/Materials: i. CAD Workstation. ii. 24" colour or mono plotter. iii. Laser Jet printer.

C. List of Software: i. Autodesk AutoCAD Mechanical (Educational network licensed latest Version). ii. Pro/Engineer or Solid edge (Educational network licensed latest Version).

D. Learning Websites. i. Autodesk Exchange/ AUGI. ii. PTC university tutorials. iii. Video tutorials from YouTube and other resources. **(Hours-8)**

TEXT BOOKS

1 Machine Drawing, K. R. Gopala Krishna Subhash Publication 2005

2 Machine Drawing, N. D. Bhat & V.M. Panchal Charoratar publishing house 2005

REFERENCE BOOKS

1. A Text Book of Computer Aided Machine Drawing, S. Trymbaka Murthy CBS Publishers, New Delhi 2007
2. Engineering drawing, P. S. Gill S K Kataria and Sons 2013
3. Machine Drawing, N. Siddeshwar, P. Kanniah, V. V. S. Sastri Tata McGraw Hill 2006

Course outcomes:
CO1. Introduce Bureau of Indian Standards on drawing practices and standard components.
CO2. Impart knowledge of machine component and its conversion into 2D drawing.
CO3. Familiarize various thread forms and representation of standard thread components.
CO4. Make aware of structural riveted joints and couplings along with their standard empirical relations.
CO5. Model parts and create assembly using standard CAD packages like Solid edge/Solid works.

Computer aided machine drawing ME-255	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2	1	1		1					2	1			
	CO2	2	2	1	1		2	1		1	2		1	1	
	CO3	3	2				1		1		2		2		
	CO4	1						2							
	CO5	1			1					1		1		2	

CS.251	DATA STRUCTURES AND ALGORTHMS LAB	L. T. P	Cr
		0 0 2	1

Course objective:
1. To relay the theoretical and practical fundamental knowledge of most commonly used algorithms

LIST OF EXPERIMENT

ARRAY OPERATIONS

1. Write a program to insert an element at given position in linear array

2. Write a program to insert an element in sorted array.
3. Write a program to delete an element from given position in linear array
4. Perform following operations on matriees using functions only
   a) Addition) b) Subtraction c) Multiplications d) Transpose

SERCHING

5. Search an element in a linear array using linear search.
6. Using iteration and recursion concepts write programs for finding the element in the array using Binary Search Method

RECURSION

7. Write a program to compute factorial of given number using recursion
8. Write a program to solve Tower of Hanoi problem using recursion
9. Write a program to find power of given number using recursion

STACK & QUEUE

10. Write a program for static implementation of stack
11. Write a program for dynamic implementation of queue
12. Write a program for static implementation of circular queue
13. Write a program for dynamic implementation of queue
14. Write a program to evaluate a postfix operation

LINKED LIST

15. Create a linear linked list & perform operations such as insert. Delete at end. at big & reverse the link list
16. Create a circular linked list & perform search, insertion & delete operation
17. Create a doubly linked list & perform search, insertion & delete operation

TREE & GRAPH

18. Write program to implement binary search tree (Insertion and Deletion in Binary Search Tree
19. Write program to simulates the various tree traversal algorithms
20. Write program to simulate various graph traversing algorithms.

Course outcomes:
CO1: Understand the concept of Dynamic memory management, data types, algorithms, big notation. CO2: Understand basic data structures such as arrays, linked lists, stacks and queues. CO3: Describe the hash function and concepts of collision and its resolution methods. CO4: Solve problem involving graphs, trees and heaps CO5: Apply Algorithm for solving problems like sorting, searching, insertion and deletion of data.

DATA STRUCTURES AND ALGORTTHMS LAB CS.251	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2	1	1		1					2	1	1		
	CO2	2	2	1			2	1		1	2		1		
	CO3	3	2				1				2		2		
	CO4	1						2							1
	CO5				1							1			2

CS.255	PYTHON PROGRAMMING LAB	L. T. P	Cr
		0 0 2	1

Course objective:
To build programming logic and thereby developing skills in problem solving using Python programming language; To be able to do testing and debugging of code written in Python Emphasize the concepts and constructs rather than on language features.

Program 1: Programs using if else structure

a) Find the Largest Among Three Numbers
b) Python Program to Check Leap Year
c) Python Program to take in the marks of 5 Subjects and Display the Grade
d) Python Program to check if a Date is Valid and Print next date

Program 2: Programs using for and while loop

a) Python Program to check whether given number is Prime Number or not
b) Python Program to find LCM of two numbers
c) Write a Python Program to compute the GCD of two numbers
d) Python Program to find the Sum of Digits in a number
e) Python Program to convert binary number to decimal numbers
f) Python Program to Display Fibonacci sequence using Recursion

Program 3: Program using List and String Data Sequence

a) Write a Python Program to input a list of Integers,
    1) Display the numbers of elements in the list

2) Display minimum and maximum element in the list
3) Display sum of square of all the elements in the list
4) Add a new element at end and display the list
5) Add a new element at given index and display list
6) Display the occurrence of given element in the list
7) Remove the given element in the list
8) Add a new element from a new list from the given list
9) Sort the given list & reverse the given list
10) Also perform slicing, concatenation and multiplication operation

b) A fruit seller sells different types of fruits. Type of fruits and corresponding rates are stored in two different lists. Customers can order any types of fruit (one or more type) in any quantity. If total bill of the customer is greater than 500, customer is given 10% discount. If any of the fruits required by the customer is not available in the store, then consider the bill amount to be -1.

Write a Python Program to calculate and display the bill amount

c) Write a Python Program to display all the permutation of the given string (don't use python permutation function)

d) Accept two strings 'string 1' and 'string 2' as input from the user. Generate a resultant string-1 such that it is a concatenated string of all upper case alphabets from the both strings in the order they appear. Generate a resultant string-2 that contains characters which are in both string 1 and 2. Print the actual resultant string 1 and resultant string 2

Program 4: Program using concepts of sets, tuple and dictionary

a) Write a Python Program that takes a string as input and store the character and occurrence of each character in a dictionary. Create two lists from the dictionary first having each character in a sorted order of their frequency and second having corresponding frequency.

b) **A furniture seller sells different type of furniture. Types of Furniture and Rates are stored in a dictionary. Customer can order any type of furniture (one or more type) in any quantity. If total bill of customer is greater than 10,000 customer is given 5% discount. 8% GST is charged on the total bill. If any of the furniture required by the customer is not available in the store, then consider the bill amount to be -1.** Write a python Program to calculate and display the bill amount.

c) Consider a scenario from Lingayas Vidyapeeth. Given below are two sets representing the names of the students enrolled for the particular course: java_course = {"Anmol","Rahil","Priyanka","Pratik'} python_ course = {"Rahul", "Ram", "Nizam","Visjal"} Write a Python Program to list the number of students enrolled for:

1) Python Couse
2) Java Course only
3) Python Course only
4) Both Java and Python Courses

5) Either Java or Python Courses but not both
6) Either Java or Python

d) Students name and their corresponding marks are stored in dictionary. Write a Python Program. Write a Python Program to perform following:
   1) Display name and marks of each student
   2) Display the name of the two top scorer
   3) Display the class average for this course
   4) Check if the marks for given student is stored in dictionary or not, if not add the name and marks in the dictionary else display his/her marks
   5) Delete the name and marks of a given student in the dictionary
   6) Add name and marks from another dictionary and display combined dictionary

Program 5: Using Function in Python:

a) Write a Python function using the concept of Keyword & Default arguments and write a program to use them

b) Write a Python function to use the concept of variable length argument & global variable. Write a program to use these functions

c) Write a recursive function to solve the Tower of Hanoi Problem

Program 6: Program using concept of Class, Object, Class variable, Class method, Static method

a) Create a class account with name, account number and balance as attribute and no_of_accounts as class variable. Account number should be generated automatically (starting from 1) using the class variable no_of_account. Add the methods for displaying the account information, depositing given amount, withdrawing given amount and initializer method to initialize the object. Create objects of Account class and call different method to test the class

b) Create a class Employee with name, empid, salary as attribute and no_of_employee and annual_incr (% annual increment) as class variable, empid should be generated automatically (starting from 1) using the class variable, no_of_employee. Add the instance methods for displaying the employee information, annually increasing the salary with help of class variable annual_incr, class method to change the value of annual_incr and initializer method to test the class program (using class method)

c) Write a Program to showing the use of built in class attributes (_doc_,dict_,_name_,_module_,_bases_) and special methods(_del_(),_str_()) and built in function is instance()

Program 7: Program using the concept of Inheritance

a) Create a class Polygon to represent a polygon having number of sides and a list having magnitude of each side as attribute. Add the input Sides () to input sides and display sides () to display sides as methods. Derive a class Triangle from Polygon and add an additional method display Area () to display area. Create object of Triangle and call different methods to test the class.

b) Create a class person having name, age, as attributes, _init_() method to initialize the object and display() to display person information. Derive a class Student from person having roll number, University name, branch as additional attributes and _init_(), display() to display student information and change_Branch() method. Create object of Student type and call different methods to test the class.

c) Write a program to show the concept of multiple inheritance in python.

Program 8: Program using the concept of Polymorphism, operator overloading

a) In a retail outlet there are two modes of bill payment
   1) Cash: Calculation includes VAT (10%) Total Amount = Purchase amount + VAT
   2) Credit Card: Calculation includes Processing Charge and VAT Total Amount = Purchase amount + VAT (10%) + Processing Charge (2%).

   The act of bill payment is same but the formula used for calculation of total amount differs as per the mode of payment. Can the Payment maker simply call a method and that method dynamically selects the formula for the total amount? Demonstrate this Polymorphic behaviour with code.

b) Write a Program to create a class to represent length in feet and inch. Overload the "+" operator to add the two object of length type.

c) Write a Program to overload comparison operator in python.

Program 9: Program on file handling in Python

a) Write a Python Program to write a few lines on file, read it back and create a dictionary having each word in file as keys in dictionary and occurrence of these word as values and print the dictionary

b) A file student .txt store student information. Information about each student is written on separate line in the form: roll number student-name (student-name may consist of any number of words). Write a Python Program that takes student roll number as input and print the student name. If roll number is not present in the file it display: "roll no not present in the file"

c) Write a Python Program to read a file that contains email ids on the separate lines in the form: personname@companyname.com. Create a new file that contain only company names, read the new file to print the company name

Program 10: Program on Exception Handling

a) Write a function divide (arg1, arg2) to divide arg1 by arg2. Use the exception handling mechanism to handle all type of possible exceptions that may occur. Take the value of arg1 and arg2 (of any type) from user as input and call the function divide to print the result of division or suitable message if any type of exception occurs (use also else and finally block)

b) Write a program to open a file in read only mode data from file and then try to write data on file. Use the exception handling mechanism to handle all type of possible exception.

c) Write a python program that takes the email id, mobile number and age as inputs from user. Validate each and use raise user defined exceptions accordingly.

Email id: there must be only one@ and at least one "."
Mobile number must be 10 digits
Age must be a positive number less than 101

Program 11: Program on Multithreading

a) Write two functions: print_even(n) and print_odd(n) to print even numbers and print odd numbers respectively up to integer n. Create two thread objects by passing these function in thread class constructor to execute these functions in two different thread. Use sleep () methods to see how these functions are executed concurrently (* use start() method to start and join() method to wait for thread to terminate)

b) Write a Python Program to use the concept of multithreading by Overriding run() method in a subclass of threading. Thread

c) Write a Python Program using the concept of thread synchronization.

REFERENCE BOOKS

1. **T.Budd Exploring Python, TMH, 1st Ed.2011**
2. **Allen Downey, Jeffrey Elkner, Chris Meyers, How to think like a computer scientist: Learning with Python,Freelyavailableonline.2012**
3. **John V Guttag "Introduction to Computation and Programing Using Python", Prentice Hall of India**

Course outcomes:
CO1: Define and demonstrate the use of built-in data structures "list" and "dictionary".
CO2: Design and implement a program to solve a real world problem.
CO3: Solve exception handling problem and files.
CO4: Make database connectivity in python programming language

PYTHON PROGRAMMING LAB CS.255	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2	1	1		1			2		2	1	1		
	CO2	2	2	1			2	1	1	1	2		1		
	CO3		2		2		1		1		2		2		
	CO4	1						2							1

Course code	**Course name**	**L**	**T**	**P**	**Cr**
PEP 201	Exploring Self	0	0	2	1

Course objective:
To gain a greater satisfaction with life through increased self-knowledge and enhanced personal identity

Module 1: Meaning of Personality – 02 hours

- Definition & Determinants
- Personality Traits
- Theories of Personality & Importance of Personality Development.
- Perception – Definition, Perceptual Process

Module 2: Self-Awareness & Self-Esteem – 06 hours

- Meaning, Benefits of Self- Awareness, Developing Self- Awareness.
- Self-Assessment, Self-Appraisal & Self-Development, Identifying Strength &Limitations; Habits, Will-Power and Drives

  Developing Self-Esteem and Building Self Confidence, Significance of Self-Discipline

Module3: Self-Assessment & Monitoring – 10 hours

- Meaning, High self- monitor versus low self- monitor
- Advantages and Disadvantages of self-monitor
- Self–monitoring and job performance.

Module4: Analysis- 8 hours

- ***SWOT Analysis:***
    - Meaning, Importance, Application, Components.
- ***Transactional Analysis***
    - Meaning – EGO States
    - Types of Transactions
    - Johari Window- Life Positions.
- ***Emotional Intelligence***
    - Meaning – Components of Emotional Intelligence
    - Significance of managing Emotional intelligence
    - How to develop Emotional Quotient.

Module5: Attitude- 8 hours

- Meaning & Formation of attitude
- Types of attitudes
- Measurement of Attitudes
- Barriers to attitude change – Methods to attitude change
- Carl Jung's contribution to personality development theory

- ***Assertiveness:***
    - Meaning – Assertiveness in Communication
    - Assertiveness Techniques
    - Benefits of being Assertive
    - Improving Assertiveness

Course outcomes:
CO1. Introspect & develop a planned approach towards profession and life in general.
CO2. Effectively set goals/target, self-motivate and practice creative thinking
CO3. Apply professional skills in order to function effectively in multi-disciplinary and heterogeneous teams through the knowledge of team work, Inter-personal relationships, conflict management and leadership quality.
CO4. Demonstrate right attitudinal and behavioral aspects for overall success inpersonal and professional life.

Exploring Self PEP 201	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2	1	1		1			2		2	1	1		
	CO2	2	2	1			2	1	1	1	2		1		
	CO3		2		2		1		1		2		2		
	CO4	1						2							1

(IV SEMESTER)

Course code	Course name	L	T	P	Cr
ME-202	Fluid Mechanics	3	1	0	4

Course objective:
It imparts the basic concept; knowledge and laws of fluid flow; Fluid dynamics and kinematics and idea of estimation of various losses encountered in fluid flow PRE REQUISITES Knowledge of Thermodynamics

UNIT-1: FLUID PROPERTIES AND FLUID STATICS

Concept of fluid and flow; ideal and real fluids; Continuum concept; properties of fluids; Newtonian and non-Newtonian fluids; Pascal's Law; hydrostatic equation; hydrostatic forces on plane and curved surfaces; stability of Floating and submerged bodies; relative equilibrium; Problems **(Hours-8)**

UNIT-2: FLUID KINEMATICS AND DYNAMICS

Eulerian and Lagrangian description of fluid flow; stream; streak and path lines; types of flows;flow rate and continuity equation; differential equation of Continuity; rotation; vorticity and circulation; stream and potential functions; Problems Concept of system and control volume; Euler's equation; Bernoulli's equation; venturimeter; pitot tubes; orifice meter; kinetic and momentum correction factors; Impulse momentum relationship and its applications; Problems **(Hours-8)**

UNIT-3: VISCOUS FLOW

Flow regimes and Reynolds's number; Relationship between shear stress and pressure gradient; uni-directional flow between stationary and moving parallel plates; Counter flow; laminar flow through pipes **(Hours-8)**

UNIT-4: FLOW THROUGH PIPES

Friction loss in pipe flow; Darcy-Weisbach formula co-efficient of friction

and friction factor: Major and minor losses in pipes; hydraulic Gradient and total energy lines; series and parallel connection of pipes; branched pipes; Equivalent pipe; power transmission through pipes; Problems

(Hours-8)

UNIT-5: BOUNDARY LAYER CONCEPT

displacement; momentum and energy thickness; von-karman momentum integral equation; laminar and turbulent boundary layer flows; drag on a flat plate; boundary layer separation; Stream lined and bluff bodies; lift and drag on a cylinder and an airfoil; Problems **(Hours-8)**

TEXT BOOKS

1. Kumar, K.L., "Engineering Fluid Mechanics", Eurasia Publication House, 2002

REFERENCE BOOKS:

1. Kumar, D. S., "Fluid Mechanics and Fluid Power Engineering", SK Kataria and Sons,1998
2. Wylie, E. B, Streeter VL; "Fluid Mechanics";McGrawHill1983
3.SomSKandBiswasG.,"IntroductiontoFluidMechanicsandFluidMachines",Ta taMcGrawHill, 1998
4. Bansal RK, "A Text Book of Fluid Mechanics" Laxmi Publications
5.Agrawal, S.K."Fluid Mechanics and Machinery",Tata McGraw Hill.

Course outcomes:
CO 1-Students will be able to understand basic knowledge of the definition and the fundamental concepts of fluid mechanics including continuum, velocity field, surface tension, flow visualization etc. CO 2-Students will able to apply the basic equation of fluid statics to determine forces on planer and curved surfaces that are submerged in a static fluid. CO 3-Students will able to use conservation laws in integral form and apply them to determine forces and moments on surfaces of various shapes and simple machines CO 4-Students will able to use Euler's and Bernoulli's equations and the conservation of mass to determine velocities, pressures, and accelerations for incompressible and in viscid fluids CO 5- Students will able design simple pipe systems to deliver fluids under specified conditions and also the loosed during the flow of the fluid.

Fluid Mechanics ME-202	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2				1					2		1		
	CO2		2	1	1			1		1					1

	CO3	3	2				1		1		2		2		
	CO4	1													
	CO5	1			1					1		1			1

Course code	Course name	L	T	P	Cr
ME-204	STRENGTH OF MATERIALS	3	1	0	4

Course objective:

1. The objective is to learn the fundamental concepts of stress, strain, and deformation of solids with applications to bars, beams, and columns.
2. The student will be able to understand torsion and bending of beams.
3. The understanding of deflection of beam under various loading condition.
4. The concept of shear force, bending moment and mohr's circle for various application conditions.

UNIT-1: Stress and Strains

Basics of stress and strain: 3-D state of stress (Concept only), Normal/axial stresses: Tensile & compressive, Tangential Stresses :Shear and complementary shear, Strains: Linear, shear, lateral, thermal and volumetric, Hooke's law, Elastic Constants: Modulus of elasticity, Poisson's ratio, Modulus of rigidity and bulk modulus and relations between them with derivation, Application of normal stress & strains, Thermal stress strain **(Hours-8)**

UNIT-2: Torsion and Bending

Torsion analysis, Torsional Equations, Concept of torsion- difference between torque and torsion., Use of torque equation for circular shaft, Comparison between solid and hollow shaft with regard to their strength and weight, Power transmitted by shaft, Bending of Beams, Bending Equations **(Hours-8)**

UNIT-3: Deflection of Beams

The elastic curve, slope and displacement by integration method, Concept of beam and form of loading, Cantilever having point load at the free end, Cantilever having point load at any point of the span, Cantilever with uniformly distributed load over the entire span, Cantilever having U.D.L. over part of the span from free end, Cantilever having U.D.L. over a part of span from fixed end, Simply supported beam with point load at centre of the span, Simply supported beam with U.D. L. over entire span **(Hours-8)**

UNIT-4: Shear Force and Bending Moment

Shear and moment diagrams, flexure formula. Concept of end supports-Roller, hinged and fixed, Concept of bending moment and shearing force, S.F. and B.M. Diagram for cantilever and simply supported beams with and without overhang subjected to concentrated load and U.D.L. **(Hours-8)**

UNIT-5: Mohr's Circle Diagram

Plane stress transformation, general equations of plane stress transformation. Plane strain, Mohr's circle. Two dimensional system, stress at a point on a plane, principal stresses and principal planes, Mohr's circle of stress and their applications. **(Hours-8)**

TEXT BOOKS

1. Ferdinand Beer, E. Johnston, John DeWolf, David Mazurek - Mechanics of Materials; Tata McGraw Hill; 2009
2. Srinath LS – Strength of materials, Macmillan, 2000

REFERENCE BOOKS

1. E.P. Popov - Mechanics of Materials, Pearson, 2015 –;
2. S Timoshenko - Strength of Materials, CBS Publishers & Distributors, Third Edition
3. Hibbeler RC – Mechanics of materials, Pearson Education, 2005

Course outcomes:
CO1.To understand fundamentals regarding Mechanics of Solids.
CO2. To develop ability of students to carry out analysis of complex state of stress.
CO3. To familiarize students about the failure modes of materials.
CO4.To enhance skills of utilizing materials of appropriate strength for mechanical engineering applications.
CO5. To familiarize the students to solve complex problems under various loading conditions

STRENGTH OF MATERIALS **ME-204**	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	1				1					2		1		
	CO2				2			1		1			1		1
	CO3	1	2	1			1		1		2		1		
	CO4	1									1				
	CO5	1			1					1		1	1		1

Course code	Course title	L	T	P	Credits
ME –206	**Computer aided measurement and inspection**	3	0	0	3

Course objective:

1. Inspection of engineering parts with various precision instruments.
2. Design of part, tolerances and fits.
3. Principles of measuring instruments and gauges and their uses.
4. To learn various concepts of instrumentation, metrology & computer assisted inspection.
5. To have practical view of various measuring, gauging instruments.

UNIT-1:
BASIC CONCEPTS OF MEASUREMENTS
Need for measurement – Dimensional and Form tolerances – Precision and Accuracy –Errors in Measurements – Causes – Types – Handling of measuring instruments –Maintenance of Instruments – Standards and Practice – Metrology lab – Environment and conditions. **(Hours-8)**

UNIT-2:
LINEAR AND ANGULAR MEASUREMENTS
Measurement of Engineering Components – Comparators, Slip gauges, Rollers, Limit gauges – Design and Applications – Angle dekkor – Alignment telescope – Sine bar –Bevel protractors – Types – Principle – Applications. **(Hours-8)**

UNIT-3:
FORM MEASUREMENTS
Measurement of Screw thread and gears – Radius measurement – Surface finish measurement – Auto collimator – Straightness, Flatness and roundness measurements– Principles – Application **(Hours-8)**

UNIT-4:
OPTICAL MEASUREMENTS
Optical microscope, interference microscope, Tool makers microscope, Vision systems, Precision instrument based on Laser – Use of Lasers – Principle – Laser Interferometer– Application in Linear and Angular measurements – Testing of machine tools using Laser Interferometer. **(Hours-8)**

UNIT-5: ADVANCES IN METROLOGY
Co-ordinate measuring machine – Constructional features – Types – Applications of CMM – CNC CMM applications – Computer Aided Inspection – Machine Vision –Applications in Metrology. Nanometrology – Introduction – Principles – Nanometer metrology systems – Methods of measuring length and surfaces to nano scale result with interferometers and other devices. Blue light sensor, white light sensor, nano measurement. **(Hours-8)**

TEXT BOOKS

1. Gaylor, Shotbolt and Sharp, "Metrology for Engineers", O.R.Cassel, London, 5th Edition, 1993.
2. R.K.Jain, "Engineering Metrology", Khanna Publishers, 19th Edition, 2005

REFERENCE BOOK

1. Thomas, "Engineering Metrology", Butthinson & Co., 1984.
2. Industrial Metrology, Graham T. Smith, Springer-Verlag London Ltd 2002
3. M.Mahajan, "A text-Book of Metrology", Dhanpat Rai & Co. (P) Ltd. 2006.

Course outcomes:
CO1.To learn various concepts of instrumentation, metrology & computer assisted inspection. CO2. To have practical view of various measuring, gauging instruments. CO3.Complete evaluation of newly developed products. CO4. Determination of Process Capabilities. CO5. Determination of the measuring instrument capabilities and ensure that they are quite sufficient for their respective measurements.

Metrology and computer aided inspection ME-206	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	1				1					1		1		
	CO2				1					1			1		
	CO3	1		1	2				1		1		1		
	CO4	1					1				1				
	CO5	1			1					1		1	1		

Course code	Course title	L	T	P	Credits
ME –208	**MANUFACTURING SCIENCE**	3	0	0	3

Course objective:

1. The main objective of this course is to emphasize the importance manufacturing sciences in the day-to-day life, and to study the ba`sic manufacturing processes and tools used.
2. The student will be having the capability of selecting suitable manufacturing processes to manufacture the products optimally.
3. The student will be able to recommend the appropriate design of gating systems, forming processes, welding process and NDT technique.
4. The student will be able to develop simplified manufacturing processes with the aim of reduction of cost and manpower.
5. The student will be able to identify/control the appropriate process parameters, and possible defects of manufacturing processes so as to remove them.

UNIT-1

INTRODUCTION: Basic manufacturing processes and safety in workshop. Classification of materials–their general mechanical properties and their selection **(Hours-8)**

UNIT-2: CASTING PROCESSES:

Sand casting process; pattern making; types of moulding sands, cores, mould making, melting and pouring of metal; Casting defects. MACHINING PROCESSES: Production of components involving turning; facing; taper turning; milling; shaping; planning and drilling operations. **(Hours-8)**

UNIT-3: METAL FORMING PROCESSES:

Sheet metal forming operations; shearing, bending, punching and blanking, forging processes as upsetting, drawing down, bending etc. **(Hours-8)**

UNIT-4: JOINING PROCESSES:

Metal arc welding; gas welding; resistance welding; soldering and mechanical fastening processes. Laser welding, MIG, TIG. oxy-acetylene welding equipment sand techniques; Electric arc welding Electrodes; manual metal arc welding; inert gas shielded arc welding, Submerged arc welding (SAW) Principle; resistance spot welding; resistance seam welding; upset welding **(Hours-8)**

UNIT-5: FITTING AND MAINTENANCE:

Study of fitting tools, marking tools and measuring instruments like micrometer, vernier calipers and height gauge; introduction to some basic maintenance techniques/processes. **(Hours-8)**

TEXT BOOK

1. Raghuwanshi, B.S., "A course in Workshop Technology, Vol. I & II", Dhanpatrai & Co.
2. Amitabh Ghosh and AK Malik, "Manufacturing Science". Second Edition, 2010.

REFERENCE BOOK

1. Hazra & Chaudhary, "Workshop Technology Vol. I & II", Asian Book Co
2. Rao P. N., Manufacturing Technology: Foundry, Forming and Welding, Tata McGraw Hill, Second Edition, 2001
3. Schey J, Introduction to Manufacturing Processes, McGraw Hill Education, 2012

MANUFACTURING SCIENCE ME-208	Course outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	1				1					2		1		
	CO2				1			1		1			1		
	CO3	1		1			1		1		2		1		
	CO4	1					1				1				
	CO5	1			1					1		1	1		

Course outcomes:

CO1.To provide an overview of the basic production techniques and allied / supporting techniques used to produce finished products from raw materials.
CO2.In addition to theory, students will be given practical training on various basic production techniques.
CO3 After going through this course, the students will be in a position to understand the working of a mechanical workshop.
CO4.To emphasize the importance manufacturing sciences in the day-to-day life.
CO5. To study the basic manufacturing processes and tools used.

EC-212	Modern Electrical & Electronics Technologies	L T P	Cr
		3 0 0	3

COURSE OBJECTIVES

1. To apply circuit theorems to simplify and find solutions to electrical circuits.
2. To build up basic problem-solving skills through organizing available information and applying circuit laws.
3.. To Simplify circuits using series and parallel equivalents and using Thevenin and Norton equivalents
4. Have a thorough understanding of the fundamental concepts and techniques used in electronics.

5. The ability to understand, analyze and design various combinational and sequential circuits.

COURSE OUTCOME At the end of the course the student should be able to

1. Simplify and identify solutions to Electronics & electrical circuits.
2. Implement the techniques to solve simple circuits
3. Categorize series and parallel equivalents and using Thevenin and Norton equivalents

Unit-1 POWER SEMI-CONDUCTOR DEVICES. Study of switching devices, SCR,

TRIAC, GTO, IGBT and IGCT- Static characteristics: SCR,

Unit-2 Network reduction: voltage and current division, source transformation, star delta conversion. Theorems: Thevenin's, Norton, Superposition, Maximum power transfer theorem, Reciprocity, Millman's theorem

Unit-3 ANALOG CIRCUITS: Diode Circuits: clipping, clamping and rectifiers. BJT and MOSFET, Current mirrors and differential amplifiers. Op-amp Circuits: Amplifiers, summers, differentiators, integrators,

Unit-4 INTRODUCTION OF GATES, COMBINATIONAL DESIGN BY USING GATES AND SIMPLIFICATION

Digital signal; logic gates: AND; OR; NOT; NAND; NOR; EX-OR; EX-NOR; Boolean algebra. Review of Number systems. Binary codes: BCD; Excess- 3; Gray; EBCDIC; ASCII; Design using gates; Karnaugh map.

Unit-5 COMBINATIONAL DESIGN USING MSI DEVICES:

Multiplexers and Demultiplexers and their use as logic elements; Decoders; Adders/Subtractors; Encoders; Sequential Circuits: Flip Flops: S-R; J-K; T; D;

Text Book

[T1] Jain, R.P., "Modern Digital Electronics", 4th Ed.; Tata McGraw Hill, 2003
[T2] Mano, Morris, "Digital Design", 3rd Edition, Prentice Hall of India,1994
[T3] Op - Amps And Linear Integrated Circuits, Ramakant A Gayakwad,PHI.
[T4] Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Pearson Education, Fourth Edition. 2014
[T5] Ned Mohan, Undeland and Robbin, "Power Electronics: converters, Application and design" John Wiley and sons, 2003.

Reference Books:

[R1] P.C Sen.," Modern Power Electronics ", S.chand, 2005.
[R2] P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003

Course code	Course title	L	T	P	Credits
ME –252	**FLUID MECHANICS LAB**	0	0	2	1

Course objective:
1. Students can able to have hands on experience in flow measurements using different devices and also perform calculation related to losses in pipes and also perform characteristic study of pumps, turbines etc.
2. The objective of this course is to enable the student to understand laws of fluid mechanics and evaluate pressure, velocity and acceleration fields for various fluid flows and performance parameters for hydraulic machinery.
3. Identify importance of various fluid properties at rest and in transit.

LIST OF EXPERIMENTS **Number of hours -13**

1. To determine the meta-centric height of a floating Body
2. To verify Bernoulli's theorem
3. To find critical Reynolds number for pipe flow
4. To determine the coefficient of discharge; contraction and velocity; of an orifice
5. To determine the coefficient of discharge of a venturimeter
6. To determine the coefficient of discharge of "V" and Rectangular notches
7. To determine the friction factor for pipes
8. To determine the minor losses due to sudden enlargement; sudden contraction and bends;Inpipe flow
9. To determine the coefficient of impact of jet
10. To determine the velocity and pressure variation with radius in a forced vortex flow

Note- The initial lab period is of introduction part for the concerned lab. The second period will be of conduct on model experimentation.

Course outcomes:
CO1.Utilize basic measurement techniques of fluid flow CO2.Demonstrate practical understanding and applications of Bernoulli's Equation CO3.Analyze the friction losses in pipes. CO4.Gaining knowledge to calculate and design engineering applications involving fluid. CO5. Understanding of analyzing flow systems in terms of mass, momentum, and energy balance.

FLUID MECHANICS LAB ME-252	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	1				1					1		1		
	CO2	1			1					1			1		
	CO3	1		1	2				1		1		1		
	CO4	1		1			1				1				
	CO5	1			1					1		1	1		

Course code	Course title	L	T	P	Credits
ME-254	**Strength of material LAB**	0	0	2	1

Course objective:
1. To expose the students to the testing of different materials under the action of tensile and compressive loads.

2. To be able to performing hardness testing by different methods.
3. To expose the students to the testing for ductility.
4. To be able to calculate the Moment Of inertia for a rotating Disc.
5. To be able to determine the dynamic property of a material

LIST OF EXPERIMENTS **Number of hours -13**

1. To perform the Brinell Hardness Test
2. To perform the Rockwell Hardness Test
3. To study the Erichsen Sheet Metal Testing Machine and Perform the Erichsen Sheet Metal Test;
4. To study the Impact Testing Machine and perform the Impact Tests (IZOD)
5. To study the Impact Testing Machine and perform the Impact Tests (CHARY)
6. To perform the Tensile Test on UTM
7. To perform the Shear Test on UTM
8. To perform the torsion test on Torsion Testing Machine
9. To determine the Moment of Inertia of a Flywheel about its own axis of rotation
10. To verify support reactions for different types of loads at different locations on the beam

Note- The initial lab period is of introduction part for the concerned lab. The second period will be of conduct on model experimentation.

Course outcomes:

CO1 Ability to understand the salient points of the stress-strain curve .
CO2. Ability to analyze the hardness and Softness.
CO3. Students will be able to determine the Modulus of rigidity .
CO4. Ability to determine Toughness.
CO5. Students will be able to verify the support reaction for a beam.

Strength of material LAB ME-254	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	1				1					1		1		2
	CO2		2		1					1			1	2	
	CO3	1		1	2		2		1		1		1		2
	CO4	1					1				1		1		2
	CO5	1			1					1		1	1	1	

V SEMESTER

Course code	Course title	L	T	P	Credits
ME-301	**MECHANICS OF MATERIALS**	3	1	0	4

Course objective:

The course should enable the students to:

1. Understand the bending stress developed in a loaded beam.
2. Understand the shear stress developed in a loaded beam.
3. Apply the knowledge to calculate slope and deflection for a loaded beam.
4. Apply the knowledge to calculate safe load for a column under various end conditions.
5. Analyze Hoop , longitudinal and radial stress for pressure vessels.

UNIT-1: BENDING STRESS

Flexural formula for straight beam under pure bending, Flexural formula for curved beam under pure bending, Development of bending stress in rectangular, I-sectional and T-sectional beams. Numerical

UNIT-2: TRANSVERSE SHEAR AND BIAXIAL STRESSES

The shear formula; shear stress in beams for rectangular cross section , shear stress in beams for I- section , Shear flow in rectangular section ,I-Section , C-section , T-section. . Numerical

UNIT-3: SLOPE AND DEFLECTION OF BEAMS

Relationship between bending moment; slope and deflection, Calculations of slope and deflection by method of integration; Calculations of slope and deflection by Macauley's method, Castigliango's theorem to find slope; deflection of beams. Numerical.

UNIT-4: COLUMNS AND STRUTS

Column under axial load, Concept of instability and buckling, slenderness ratio; Euler's formula for elastic buckling load for a column hinged at both the ends, Euler's formula for elastic buckling load for a column fixed at one end and free at other end, Euler's formula for elastic buckling load for a column fixed at both ends, Euler's formula for elastic buckling load for a column fixed at one end and hinged at other end, Equivalent length of a column, Slenderness Ratio, Rankines formula. Numerical.

UNIT-5: THIN & THICK CYLINDERS

Thin walled pressure vessels; Hoop stress and longitudinal stress for A thin cylindrical vessel ,Hoop stress and longitudinal stress for a thin spherical vessel, Derivations of Lame's equations for thick cylinders; Radial and hoop stresses and strains in thick cylinders,

TEXT BOOKS

Ferdinand P Beer & Russel E Johnston;—Mechanics of Materials, Tata McGraw Hill;2009

REFERENCE BOOKS:

1. Hibbeler, R. C.,— Mechanics of Materials ,Pearson Education, 2005
2. Ryder,G H., —Strength of Materials‖, Macmillan, 2001
3. Srinath LS, —Strength of Materials‖, Macmillan, 2001

Andrew / Kiusalaas, Jaan., —Mechanics of Materials‖, Thomson, 2003

Course outcomes:
CO1.Sutdents will be able to Determine Beam deflections using various theorem. CO2.Students will be able to analyze induced stresses in thin and thick cylinders CO3. Students will be able to design column by analyzing the Buckling loads in Columns and struts. CO4. Students will be able to design Beam with respect to bending stress. CO5. Students will be able to design Beam with respect to shear stress.

Mechanics of materials. ME -301	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2	1	1		1					2	1	1		1
	CO2	2	2	1			2	1		1	2		1		
	CO3	3	2		2		1				2		2	2	
	CO4	1			1			2	2		2	2		2	1
	CO5				1	2			1			1			2

Course code	Course title	L	T	P	Credits
ME-303	ManufacturingTechnology	3	0	0	3

Course objective:
1. To gain theoretical and practical knowledge in material casting processes and develop an understanding of the dependent and independent variables which control materials casting in a production setting.

2. Introduce students to good foundry practices and product design considerations.

3. Provide an overview of joining processes; discuss in detail the weld the welding process and thephysics of welding.

UNIT-1: Introduction

Fundamental Concept of Quality, Role of Inspection and Measurement for Quality Control in Manufacturing. Advantages and limitations; sand mold making procedure; patterns And core; pattern materials; pattern allowances; types of patterns **(Hours-8)**

UNIT-2: Non-destructive inspection-I and casting defects

Non-destructive inspection-i: visual inspection, dye penetrant inspection, magnetic particle inspection, eddy current inspection, ultrasonic testing. Types of cores; core prints ; chaplets and chills; Gating system; gates and risers; Melting practice; cupola and induction furnace; charge calculations; casting cleaning and casting defects; fettling; defects in casting and their remedies; methods of testing of casting for their soundness **(Hours-8)**

UNIT-3: Non-destructive inspection-II and casting process

Non-destructive Inspection-II: Acoustic Emission Inspection, Radiography, Leak Testing, Thermographic Non-destructive Testing .Shell molding; precision investment casting; permanent mold casting; die casting; centrifugal casting; and continuous casting. **(Hours-8)**

UNIT-4: Engineering Metrology and moulds

Linear Measurement, Angular Measurement. Classification and Properties of Plastics, Principle, Selection Operation, Advantages and Limitations of various Moulding Processes, Design Considerations for plastic moulded parts **(Hours-8)**

UNIT-5: Measurement

Measurement of Surface Finish, Screw Thread Metrology, Gear Measurement. Classification;

TEXT BOOKS

1. Rao PN., "Manufacturing Technology – Foundry, Forming and Welding", Tata McGraw Hill

REFERENCE BOOKS:

1. Measurement and metrology by R k. Rajput

2. Ghosh. A. Mallik A.K., "Manufacturing Science", Affiliated East West Press, 2005

3. Sinha, K P, Goel D B., "Foundry Technology", Standard Publishing, New Delhi, 2005

4. Richard, L Little., "Welding and Welding Technology", Tata McGraw Hill, 2000

5. Rosenthal; "Principle of Metal Casting", Tata McGraw Hill, 2001

Raghuwanshi B S., " Workshop Technology", VolI., Dhanpat Rai, 2004

Course outcomes:
CO1. Discuss Concept of Quality, Role of Inspection and Measurement. CO2. Explain the Non-destructive inspection-I and casting defects and its application. CO3. Discuss various types of acoustic Emission Inspection and mold casting. CO4. Discuss various types of engineering measurements and Design Considerations for plastic moulded parts. CO5. Classify and explain advance welding processes and its application.

Manufacturing technology ME-303	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	1	1	2		1	1	2	1		1	2	2	2	
	CO2	2	1	2		1	1	2	1		1	3	1		
	CO3	2		2			1	1		2	1	2	1		
	CO4	1		1	2		1		1	2		3	2	1	
	CO5	2	1		2		1	3		2		1	1		

Course code	Course title	L	T	P	Credits
ME-305	**HEAT TRANSFER**	3	1	0	4

Course objective:
1. This course imparts basic knowledge of heat transfer. 2. The knowledge imparted will equip the students with preliminary design of heat exchanger. 3. To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries 4. This course is designed to introduce a basic study of the phenomena of heat and mass transfer, to develop methodologies for solving a wide variety of practicals. 5. This course is intended to provide students the basic principles and applications of heat transfer to engineering problems

UNIT-1: BASICS AND LAWS

Modes of heat transfer, Steady State Heat Conduction: Boundary conditions in heat transfer; I-D heat conduction: a plane wall; long hollow cylinder; hollow sphere and composite structures; Overall htc. Conduction equation in Cartesian; polar and spherical co-ordinate systems; Initial and Boundary conditions; Critical Thickness of Insulation, Log Mean Area of Cylinder sand Spheres, Numerical problems. **(Hours-8)**

UNIT-2: STEADY STATEANDUNSTEADY STATEHEAT CONDUCTION

Introduction;1–D heat conduction with heat sources; Plane wall; hollow cylinder and sphere; Current carrying conductor ;Extended surfaces(fins);Fin effectiveness Numericals, Systems with negligible internal resistance; Transient heat conduction in plane walls; cylinders; spheres with convective boundary Conditions; Chart solutions only; Periodic heat transfer in one dimension; Numericals **(Hours-8)**

UNIT-3: CONVECTION (WITH AND WITHOUT PHASE CHANGE)

Forced convection-Thermal and hydro-dynamic boundary layers; Equation of continuity; Momentum and energy equations; some results for flow over a flat plate and flow through tube; Fluid friction and heat transfer (Colburnanalogy);Use of; Empirical relations for free convection from vertical and horizontal planes and cylinders; Numericals, Laminar film condensation on a vertical plate; Drop-wise condensation; Boiling regimes; Free convective; Nucleate and film boiling; Numericals **(Hours-8)**

UNIT-4: THERMAL RADIATION

Absorptivity; Reflectivity; Transmissivity; Black body; emissive power; radiosity; laws of thermal radiation; intensity of radiation; Shape factor and its properties; Hottel's Method; Radiation exchange between black and gray surfaces; Two body; three body enclosures; Radiation shielding; Numericals

UNIT-5: HEAT EXCHANGERS

Classification; Performance variables; Analysis of a parallel and counter flow heat exchanger using LMTD and NTU; Heat exchanger effectiveness; Use of charts for multipass exchanger and Cross flow heat exchanger; Fouling factor; Compact heat exchangers; Plate heat exchangers; Heat Pipe, Numericals **(Hours-8)**

TEXT BOOK

1. NAG, P. K., "Heat Transfer", McGraw Hill

REFERENCE BOOKS

1. Arpasi, VS., "Conduction Heat Transfer", Addison Wesley
2. Domkundwar., "Heat Transfer",
3. Holman, J. P., "Heat Transfer", Tata McGraw Hill
4. Goshdastidar, P.S., "Heat Transfer", Oxford Univ Press
5. Lienhard, J.V, J. H. Lienhard. V., " A Heat Transfer Text Book

Course outcomes:
CO-1: To develop solutions for transient heat conduction in simple geometries, without heat generation. CO-2: Understand the fundamentals of convective heat transfer process; evaluate heat transfer coefficients for natural and forced convection; deriving and analysing momentum and energy equations in two dimensions. CO-3: Analysis of dimensionless quantities of heat transfer. CO-4: Upon completion of this course, the students can able to understand and apply different heat and mass transfer principles of different applications. CO-5. Students can able to understand the various heat transfers and also the Heat exchangers.

HEAT TRANSFER ME-305	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2	1	2	1	1	2				2	3	1		
	CO2		2	1	1	2	2		1		1	3	2		
	CO3	2	2	2			2	2		2	1	3	3		2
	CO4	2						1	1	1		2	3		2
	CO5	2	1		2		1	3		2		2	2		

Course code	Course title	L	T	P	Credits
ME-307	Management science and productivity	3	0	0	3

Course objective:
1. This course is intended to familiarise the students with the framework for the managers and leaders availbale for understanding and making decisions realting to issues related organiational structure, production operations, marketing, Human resource Management, product management and strategy.

UNIT 1. INTRODUCTION TO MANAGEMENT

Management -Concept and meaning -Nature-Functions -Management as a Science and Art and both. Schools of Management Thought -Taylor's Scientific Theory-Henry Fayol's principles -Eltan Mayo's Human relations -Systems Theory -Organisational Designs -Line organization -Line & Staff Organization -Functional Organization -Matrix Organization -Project Organization -Committee form of Organization -Social responsibilities of Management.

UNIT 2 OPERATIONS MANAGEMENT

Principles and Types of Plant Layout -Methods of Production (Job, batch and Mass Production), Work Study -Statistical Quality Control-Deming's contribution to Quality. Material Management -Objectives -Inventory-Functions -Types, Inventory Techniques -EOQ-ABC Analysis -Purchase Procedure and Stores Management -Marketing Management -Concept -Meaning -Nature-Functions of Marketing -Marketing Mix -Channels of Distribution -Advertisement and Sales Promotion -Marketing Strategies based on Product Life Cycle

UNIT 3 HUMAN RESOURCES MANAGEMENT (HRM)

HRM -Definition and Meaning –Nature -Managerial and Operative functions -Evolution of HRM -Job Analysis -Human Resource Planning(HRP) -Employee Recruitment-Sources of Recruitment -Employee Selection -Process and Tests in Employee Selection -Employee Training and Development -On-the-job & Off-the-job training methods -Performance Appraisal Concept -Methods of Performance Appraisal –Placement -Employee Induction -Wage and Salary Administration

UNIT 4 STRATEGIC & PROJECT MANAGEMENT

Definition& Meaning -Setting of Vision -Mission -Goals -Corporate Planning Process -Environmental Scanning -Steps in Strategy Formulation and Implementation -SWOT Analysis -Project Management -Network Analysis -Programme Evaluation and Review Technique

(PERT) -Critical Path Method (CPM) Identifying Critical Path -Probability of Completing the project within given time -Project Cost-Analysis -Project Crashing (Simple problems).

UNIT 4 CONTEMPORARY ISSUES IN MANAGEMENT

The concept of Management Information System(MIS) -Materials Requirement Planning (MRP) -Customer Relations Management(CRM) -Total Quality Management (TQM) -Six Sigma Concept -Supply Chain Management(SCM) -Enterprise Resource Planning (ERP) -Performance Management -Business Process Outsourcing (BPO) -Business Process Re-engineering and Bench Marking -Balanced Score Card -Knowledge Management.

Text Books

1. A.R Aryasri, "Management Science", TMH,
. Stoner, Freeman, Gilbert, Management, Pearson Education, New Delhi, 2012.

Reference Books

1. Koontz & Weihrich, "Essentials of Management", 6thedition, TMH, 2005.
2. Thomas N.Duening & John M.Ivancevich, "Management Principles and Guidelines", Biztantra.
3. Kanishka Bedi, "Production and Operations Management", Oxford University Press, 2004.
4. Samuel C.Certo, "Modern Management", 9thedition, PHI, 2005

Course outcomes:
CO1. Able to apply the concepts & principles of management in real life industry. CO2. Able to design & develop organization chart & structure for an enterprise. C03. Able to apply PPC techniques, Quality Control, Work-study principles in real life industry.

Management science and productivity ME 307	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2				1					1	2	2		
	CO2					1	1	2			2	3	1		
	CO3	2		3			1	1		2	1	2	1	1	

Course code	Course title	L	T	P	Credits
ME-309	**FLUID MACHINERY**	3	1	0	4

Course objective:
1. The students completing this course are expected to understand the properties of fluids, its kinematic and dynamic behavior through various laws of fluids like continuity, Euler's,Bernoulli's equations, energy and momentum equations. Further, the student shall be able to understand the theory of boundary layer, working and performance characteristics of various hydraulic machines like pumps and turbine

UNIT-1: IMPACT OF FREE JETS

Impulse– momentum principle; jet impingement-on a stationary flat plate; inclined plate and a hinged plate; at the center of a stationary vane; on a moving flat plate; inclined plate; a moving vane and a series of vanes; Jet striking tangentially at the tip of a stationary vane and moving vane(s); jet propulsion of ships Problems

UNIT-2: IMPULSE TURBINES

Classification – impulse and reaction turbines; water wheels; component parts; construction; operation and governing mechanism of a Pelton wheel; work done; effective head; available head and efficiency of a Pelton wheel; design aspects; speed ratio; flow ratio; jet ratio; number of jets; number of buckets and working proportions; Performance Characteristics; governing of impulse turbines. Problems

UNIT-3: REACTION TURBINE

Francis Turbines: Component parts; construction and operation of a Francis turbine; governing mechanism; work done by the turbine runner; working proportions and design parameters; slow; medium and fast runners; degree of reaction; inward/outward flow reaction turbines; PerformanceCharacteristics; Problems.

Propeller and Kaplan turbines: Component parts; construction and operation of a Propeller; Kaplan turbine; differences between the Francis and Kaplan turbines; draft tube-its function and different forms; Performance Characteristics; Governing of reaction turbine;

UNIT-4: CENTRIFUGAL PUMPS

Centrifugal Pumps: Classification; velocity vector diagrams and work done; manometry efficiency; vane shape; head capacity relationship and pump losses; pressure rise in impeller; minimum starting speed; design considerations; multi-stage pumps. Similarity relations and specific speed; net positive suction head; cavitation and maximum suction lift; performance characteristics; Brief introduction to axial flow; mixed flow and submersible pumps; Problems.

UNIT-5: RECIPROCATING PUMPS

Reciprocating Pumps: Construction and operational details; discharge coefficient; volumetricefficiency and slip; work and power input; effect of acceleration and friction on indicator diagram (pressure–stroke length plot); separation; air vessels and their utility; rate of flow into or from the air vessel; maximum speed of the rotating crank; characteristic curves; centrifugal V/Sreciprocating pumps; brief introduction to screw; gear; vane and radial piston pumps; Problems. Hydraulic systems: Function; construction and operation of Hydraulic accumulator; hydraulicintensifier; hydraulic crane; hydraulic lift and hydraulic press; Fluid coupling and Torque converter; Hydraulic ram; Problems.

TEXT BOOKS

1. Hydraulics & Fluid Mechanics– Modi & Seth; Pub.-Standard Book House; N. Delhi
2. Hydraulic Machines–Jagdish Lal; Metropolitan

REFERENCE BOOKS:

1. Fluid Mechanics and Hydraulic Machines – SS Rattan; Khanna Publishers
2. Introduction to Fluid Mechanics and Fluid Machines– SK Som and G Biswas; Tata McGraw Hill
3. Fluid Mechanics and Fluid Power Engineering– D S Kumar; SK Kataria and Sons

Course outcomes:

CO1.Students can able to Examine Single Acting &Double Acting Compressor

CO2.Students can able to understand the basic concepts of Gas power cycles

CO3. Students can able to compare various steam Turbine & Steam Nozzle

CO4. An overall idea about fluid machinery and the knowledge about the calculation of efficiency,power developed by a turbines and power required by a pump.

CO-5: Able to understand basic working principles of various hydraulic machines

FLUID MACHINERY ME 309	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2				1					1	2	2		
	CO2					1	1	2			2	3	1		
	CO3	2		3			1	1		2	1	2	1	1	
	CO4		1				1								
	CO5									1					

Course code	Course title	L	T	P	Credits
ME-359	**FLUID MACHINERY LAB**	0	0	2	1

Course Objectives:
To have hands on experience in flow measurements using different devices and also perform characteristic study of pumps, turbines etc.,

LIST OF EXPERIMENTS

1. To study the constructional details and draw characteristic and constant efficiency curves ofPelton turbine
2. To study the constructional details and draw characteristic and constant efficiency curvesof a Francis turbine
3. To study the constructional details and draw characteristic and constant efficiency curves ofa Kaplan turbine
4. To study the constructional details and draw characteristic curve of centrifugal pump
5. To study the constructional details and draw characteristic curve of a reciprocating pump
6. To study the constructional details and draw performance curve of gear oil pump
7. To study the constructional details and determine the efficiency of a hydraulic Ram
8. To study the constructional details of a centrifugal compressor
9. To study the model of hydro power plant and draw it's layout
10. To determine the volumetric efficiency of a reciprocating compressor

Course outcomes:

CO1.Ability to use the measurement equipment's for flow measurement
CO2.Ability to use the measurement equipment's for flow measurement CO3.Ability to do performance trust on different fluid machinery
CO4. Identify importance of various fluid properties at rest and in transit. Understand the concept of boundary layer theory and flow separation. Plot velocity and pressure profiles for any given fluid flow.
CO5. Evaluate the performance characteristics of hydraulic turbines and pumps

FLUID MACHINERY LAB ME 359	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2				1					1	2	2		
	CO2					1	1	2			2	3	1		
	CO3	2		3			1	1		2	1	2	1	1	
	CO4		1				1								
	CO5									1					

Course code	Course title	L	T	P	Credits
ME-353	Manufacturing Technology Lab	0	0	2	1

Course objective:
1. To impart hands-on practical exposure on manufacturing processes and equipment.

LIST OFEXPERIMENTS **Total number of hours 13**

1. To make a pattern for a given casting with all the necessary allowances

2. To make a component involving gas welding joints and to study the welding defects and suggesting their remedies.

3. To make a component involving MIG welding and study the welding defects and suggest their Remedies.

4. Development and manufacture of a Complex sheet metal component such as, five piece elbow

5. To make a casting of aluminium material.

6. To study defects in a casting and suggest the remedial measures.

7. To make a sand mould with a core for making a hollow job.

Note- The initial lab period is of introduction part for the concerned lab. The second period will be of conduct on model experimentation.

Course outcomes:
CO1. Students will understand lathe and its working
CO2. Students will get aware about different tools used in manufacturing.
CO3. Student will understand the concept of tool wear.
CO4. Students will learn the use of machineries.
CO5. Students will learn the different methods of manufacturing

MANUFACTURING TECHNOLOGY LAB ME-353	**Course outcome**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2				1					1	3	2		
	CO2					2	1	2			2	3	1	1	
	CO3	2		3			2	2		2	1	3	1		
	CO4	1		1	2		2		1	2	3		2		
	CO5	2	1		2		1	3		2		1	1		

Course code	Course title	L	T	P	Credits
ME-355	**HEAT TRANSFER LAB**	0	0	2	1

Course Objectives:

1. To study the heat transfer phenomena predict the relevant coefficient using implementation.
2. To study the performance of refrigeration cycle / components.
3. Analyze different methods to calculate the heat transfer coefficient in various heat transfer problems.
4. Analyze the theoretical knowledge and apply it in conducting experiments in the forms of heat transfer.

LIST OF EXPERIMENTS **Total number of hours 13**

1. To determine the thermal conductivity of a metallic Rod. To determine thethermal conductivity of an insulating power
2. To find out the heat transfer and effectiveness of a pin fin under naturalconvection condition
3. To calculate the heat transfer and effectiveness of a pin fin under forcedconvection condition
4. To determine the emissivity of a given specimen body
5. To verify the Stefen-Boltzman constant for thermal radiation
6. To determine the overall heat transfer coefficient and effectiveness of a givenheat exchanger under parallel flow condition
7. To determine the overall heat transfer coefficient and effectiveness of a givenheat exchanger under counter flow condition
8. To determine the convective heat transfer coefficient for a horizontal rod
9. To determine the overall thermal resistance of a composite wall

Note- The initial lab period is of introduction part for the concerned lab. The second period will be of conduct on model experimentation.

Course outcomes:

CO1. Ability to demonstrate the fundamentals of heat and predict the coefficient used in that transfer application and also design refrigeration cycle.

CO2. Students can apply their heat transfer knowledge in industries.

CO3. Analyze different methods to calculate the heat transfer coefficient in various heat transfer problems.

CO4. Analyze the theoretical knowledge and apply it in conducting experiments in the forms of heat transfer Test Emissivity, Stefan Boltzmann Constant and Critical Heat flux.

CO5. Asses the performance of Refrigeration and Air conditioning and to determine the overall heat transfer coefficient for a composite slab.

HEAT TRANSFER LAB ME- 355	Course outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
	CO1	2	2			1			2		1	2	2		
	CO2		2			1	1	2			2	3	2		
	CO3	2		3					2	2			1		2
	CO4	1		1	2		1		1	2	3		2		1
	CO5	2	1		2		1	3		2		1	1		

Course code	Course title	L	T	P	Credits
PEP-301	Leadership & Management Skills	1	0	2	2

Course Objectives:

1. Help students to develop essential skills to influence and motivate others
2. Inculcate emotional and social intelligence and integrative thinking for effective Leadership
3. Create and maintain an effective and motivated team to work for the society
4. Nurture a creative and entrepreneurial mindset
5. Make students understand the personal values and apply ethical principles in professional and social contexts

Module 1- Leadership Skills 4 Hours

a. Understanding Leadership and its Importance

- What is leadership?
- Why Leadership required?
- Whom do you consider as an ideal leader?

b. Traits and Models of Leadership

- Are leaders born or made?
- Key characteristics of an effective leader
- Leadership styles

- Perspectives of different leaders

c. Basic Leadership Skills

- Motivation
- Team work
- Negotiation
- Networking

Module 2 - Managerial Skills 6 Hours

a. Basic Managerial Skills

- Planning for effective management
- How to organise teams?
- Recruiting and retaining talent
- Delegation of tasks
- Learn to coordinate
- Conflict management

b. Self-Management Skills

- Understanding self-concept
- Developing self-awareness
- Self-examination
- Self-regulation

Module 3 - Entrepreneurial Skills 4 Hours

a. Basics of Entrepreneurship

- Meaning of entrepreneurship
- Classification and types of entrepreneurships
- Traits and competencies of entrepreneur

b. Creating Business Plan

- Problem identification and idea generation
- Idea validation
- Pitch making

Module 4 - Innovative Leadership and Design Thinking 6 Hours

a. Innovative Leadership

- Concept of emotional and social intelligence
- Synthesis of human and artificial intelligence
- Why does culture matter for today's global leaders

b. Design Thinking

- What is design thinking?
- Key elements of design thinking:
  - Discovery
  - Interpretation
  - Ideation
  - Experimentation
  - Evolution.
- How to transform challenges into opportunities?
- How to develop human-centric solutions for creating social good?

Module 5- Ethics and Integrity 4 Hours

a. Learning through Biographies

- What makes an individual great?
- Understanding the persona of a leader for deriving holistic inspiration
- Drawing insights for leadership
- How leaders sail through difficult situations?

b. Ethics and Conduct

- Importance of ethics
- Ethical decision making
- Personal and professional moral codes of conduct
- Creating a harmonious life

Books

- Ashokan, M. S. (2015). Karmayogi: A Bbiography of E. Sreedharan. Penguin, UK.
- Brown, T. (2012). Change by Design. Harper Business
- Elkington, J., & Hartigan, P. (2008). The Power of Unreasonable People: How Social EntrepreneursCreate Markets that Change the World. Harvard Business Press.
- Goleman D. (1995). Emotional Intelligence. Bloomsbury Publishing India Private

Limited

• Kalam A. A. (2003). Ignited Minds: Unleashing the Power within India. Penguin Books India

• Kelly T., Kelly D. (2014). Creative Confidence: Unleashing the Creative Potential Within Us All.

William Collins

• Kurien V., & Salve G. (2012). I Too Had a Dream. Roli Books Private Limited

• Livermore D. A. (2010). Leading with cultural intelligence: The New

Secret to Success. New York:American Management Association

• McCormack M. H. (1986). What They Don't Teach You at Harvard

Business School: Notes From AStreet-Smart Executive. RHUS

• O'Toole J. (2019) The Enlightened Capitalists: Cautionary Tales of

Business Pioneers Who Tried toDo Well by Doing Good. Harpercollins

• Sinek S. (2009). Start with Why: How Great Leaders Inspire Everyone to Take Action. Penguin

• Sternberg R. J., Sternberg R. J., & Baltes P. B. (Eds.). (2004).

International Handbook ofIntelligence. Cambridge University

Press.

E-Resources

• Fries, K. (2019). 8 Essential Qualities That Define Great Leadership.

Forbes. Retrieved 2019- 02-15 from

https://www.forbes.com/sites/kimberlyfries/2018/02/08/8-

essentialqualities-that-define-great- leadership/#452ecc963b63.

• How to Build Your Creative Confidence, Ted Talk by David Kelly -

https://www.ted.com/talks/david_kelley_how_to_build_your_creative_c

onfidence

• India's Hidden Hot Beds of Invention Ted Talk by Anil Gupta -

https://www.ted.com/talks/anil_gupta_india_s_hidden_hotbeds_of_inve

ntion

• Knowledge@Wharton Interviews Former Indian President APJ Abdul

Kalam - ."A Leader Should Know How to Manage Failure"

https://www.youtube.com/watch?v=laGZaS4sdeU

• Martin, R. (2007). How Successful Leaders Think. Harvard Business Review, 85(6): 60.

• NPTEL Course on Leadership - https://nptel.ac.in/courses/122105021/9

Course outcomes:
CO1. Examine various leadership models and understand/assess their skills, strengths and abilities that affect their own leadership style and can create their leadership vision CO2. Learn and demonstrate a set of practical skills such as time management, self-management, handling conflicts, team leadership, etc. CO3. Understand the basics of entrepreneurship and develop business plans CO4. Apply the design thinking approach for leadership CO5. Appreciate the importance of ethics and moral values for making of a balanced personality.

Leadership & Management Skills PEP 301	**Course outcomes**	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
	CO1	2	2			1			2		1	2	2		
	CO2		2			1	1	2			2	3	2		
	CO3	2		3					2	2			1		2
	CO4	1		1	2		1		1	2	3		2		1
	CO5	2	1		2		1	3		2		1	1		

(VI SEMESTER)

Course code	Course title	L	T	P	Credits
ME-302	**CAD/CAM/CIM**	3	0	0	3

Course Objectives:
1. Students will be introduced to CAD/CAM/CAE concepts. 2. Student will be introduced to CAPP 3. Students will learn about importance of data generation and management in CIMS. 4. Student will be introduced to CAPP 5. Student will learn steps in upgrading from FMS to CIM.

UNIT1:INTRODUCTION (Hours-8)

BRIEF INTRODUCTION TO CAD and CAM Manufacturing Planning, Manufacturing control Introduction to CAD/CAM , Concurrent Engineering , CIM concepts ,Computerized elements of CIM system ,Types of production , Manufacturing models and Metrics, Mathematical models of Production Performance , Manufacturing Control , Basic Elements of an Automated system , Levels of Automation , Lean Production and Just-In Time Production , Numerical.

UNIT 2: PRODUCTION PLANNING AND CONTROL AND COMPUTERISED PROCESSPLANNING (Hours-8)

Process planning , Computer Aided Process Planning (CAPP) , Logical steps in Computer Aided Process Planning , Aggregate Production Planning and the Master Production Schedule , Material Requirement planning , Capacity Planning- Control Systems-Shop Floor Control Inventory Control , Brief on Manufacturing Resource Planning-II (MRP-II) & Enterprise Resource Planning (ERP) , Numerical.

UNIT 3: CELLULAR MANUFACTURING (Hours-8)

Group Technology (GT), Part Families , Parts Classification and coding , Opitz Part Coding system, Production flow Analysis, Cellular Manufacturing , Composite part concept, Machine cell design and layout , Quantitative analysis in Cellular Manufacturing ,Rank Order Clustering Method , Arranging Machines in a GT cell , Hollier Method , Numerical.

UNIT 4: FLEXIBLE MANUFACTURING SYSTEM (FMS) AND AUTOMATED GUIDEDVEHICLE SYSTEM (AGVS) (Hours-8)

Types of Flexibility-FMS , FMS Components , FMS Application & Benefits , FMS Planning and Control, Quantitative analysis in FMS, Simple Problems. Automated Guided Vehicle System (AGVS) , AGVS Application , Vehicle Guidance technology , Vehicle Management & Safety.

UNIT-5: CNC MACHINE TOOLS (Hours-8)

Introduction; types of CNC systems; Numerical Control Machine tools; CNC types; constructional details; special features; Part programming fundamentals; manual programming and computer assisted part programming.G coding, M coding.

TEXT BOOK:

1. Mikell.P.Groover "Automation, Production Systems and Computer IntegratedManufacturing", Prentice Hall of India, 2012.

2. Radhakrishnan P, Subramanyan S.and Raju V., "CAD/CAM/CIM", 2nd Edition, NewAge International (P) Ltd, New Delhi, 2008.

REFERENCES:

1. Dr.K.c.Jain , " CAD/CAM/CIM" , Khanna Publisher
2. Alavala Chennakesava R. , CAD/CAM ' , PHI learning Publisher
3. E. Zimmers, M. Groover , CAD/CAM ,- Pearson

Course outcomes:

CO1.Students will be able to apply knowledge about various methods.
CO2.Students will be able to apply knowledge about Computer Aided Quality control.
CO3.Students will be able to apply knowledge about Process Planning Control.
CO4. Students will be able to Design Flexible manufacturing cell after carrying out Grouptechnology study and finally creating FMS.
CO5. To design a system, components, or process and meet specific objectives keeping in view the economical approaches, availability of materials and manufacturability with increased life.

CAD/CAM/CIM ME-302	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	1	2						1	1	2	3	1		
	CO2	1	1	2	1	1	1	2				3	2	2	
	CO3	2	1					2	2	1	1	3	3	2	
	CO4	1	2			2	1	1				2	3		
	CO5	1	1		2	2			2	2	2	2	2		

Course code	Course title	L	T	P	Credits
ME-304	Theory of Machine	3	1	0	4

Course objective:

1. To understand the basic components and layout of linkages in the assembly of a system/machine.
2. To understand the basic concepts of toothed gearing and kinematics of gear trains.
3. To understand the force-motion relationship in components subjected to external forces and analysis of standard mechanisms.
4. To identify and enumerate different link based mechanisms with basic understanding of motion
5. To interpret and analyse various velocity and acceleration diagrams for various mechanisms

UNIT-1: INTRODUCTION OF MECHANISMS AND MACHINES

Concepts of Kinematics and Dynamics, Mechanisms and Machines, Planar and Spatial Mechanisms, Kinematic Pairs, Kinematic Chains, Kinematic Diagrams, Kinematic Inversion, Four bar chain and Slider Crank Mechanisms. And their Inversions, Degrees of Freedom,

Mobility and range of movement-Kutzbach and Grubler's criterion, Transmission angle, Mechanical Advantage. **(Hours-8)**

UNIT-2: Cams and Followers

Cams and Followers: Introduction: Classification of cams and followers, nomenclature, displacement diagrams of follower motion. Synthesis and Analysis: Determine of basic dimensions and synthesis of cam profiles using graphical methods, cams with specified contours. **(Hours-8)**

UNIT-3: Gears and Gear Trains

Gears: Terminology, Law of Gearing, Characteristics of involute and cycloid action, Interference and undercutting, center distance variation, minimum number of teeth, path of contact, contact ratio,

Gear Trains: Synthesis of Simple, compound &reverted gear trains, Analysis of epicyclical gear trains.

UNIT-4: Static and Dynamic Force Analysis

Static force analysis of planer mechanisms, dynamic force analysis including inertia and frictional forces of planer mechanisms. Dynamics of Reciprocating Engines: engine types, indicator diagrams, gas forces, equivalent masses, inertia forces, bearing loads in a single cylinder engine, crankshaft torque, engine shaking forces. Introduction to flywheel.**(Hours-8)**

UNIT-5: Governors and Balancing of Rotating Components

Watt, Porter, Proell, Hartnell and spring controlled governors, governor effort, power, stability, inertia effects. Hunting of governors and Isochronism, Inertia Governors, Static/dynamic balancing; Balancing of rotating masses; Two plane balancing –graphical and analytical methods; balancing of rotors; field balancing; balancing machines. **(Hours-8)**

TEXT BOOKS:

1. Rattan S.S, Theory of Machines,Tata McGraw-Hill Publishing Company Ltd., New Delhi, 4th Edition, 2014.
2. Ambekar A. G., Mechanism and Machine Theory, PHI, 2009.
3. V P Singh, "Theory of Machines", Dhanpat Rai & Co. (P) Ltd.
4. Singh Sadhu, "Theory of Machines", Pearson Education.

REFERENCE BOOKS

1. Jagdishlal, "Theory of Machines", Metropolitan book.
2. J J Uicker, G R Pennock, J E Shigley, "Theory of Machines and Mechanisms", Oxford Press.
3. R L Norton, "Kinematics and Dynamics of Machinery", Tata McGraw-Hill publishing co.

Course outcomes:
CO1. Classify the basic components and layout of linkages in the assembly of a system/machine. CO2. Explain the basic concepts of toothed gearing and kinematics of gear trains. CO3. Apply vector mechanics as a tool for solving kinematic problems. CO4. Illustrate undesirable effects of unbalances resulting from prescribed motions in mechanism. CO5. Discuss balancing, graphical and analytical methods.

Theory of Machine ME-304	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2	1	2		1	2	2	1		1	3	1		
	CO2	2	2		1		2		1		1	3	2		
	CO3	2		1			2	1		2	1	3	1		
	CO4	2		1	2		1		1	1		2	1		
	CO5	2	1		2		1	1		1		1	1		

Course code	Course title	L	T	P	Credits
ME-306	**Mechatronics and automation**	3	0	0	3

Course Objectives:
1. Enhancing the innovation and inventions in mechatronics engineering. **2.** Gain Knowledge about various types of sensors. **3.** Gain Knowledge about various types of Actuator Mechanisms. **4.** Gain Knowledge about system models. **5.** Gain Knowledge about various types of controllers.

UNIT-1: Introduction to Mechatronics (Hours-8)

Introduction, Examples of Mechatronic systems, Electric circuits and components, Semiconductor Electronics, Transistor Applications

UNIT-2: Sensors and transducers (Hours-8)

Performance terminology of sensors,Displacement, Position & Proximity Sensors-I, Displacement, Position & Proximity Sensors-II, Force, Fluid pressure, Liquid flow sensors, temperature, light sensor, Acceleration and Vibration measurement

UNIT-3: Actuators and mechanisms (Hours-8)

Mechanical Actuation System, Hydraulic & Pneumatic Actuation System, Electrical Actuation System-I, Electrical Actuation System-II, Data Presentation system

UNIT-4: Modeling and system response (Hours-8)

Mechanical system model, Electrical system model, Fluid system model, Dynamic response of systems, Transfer function and frequency response

UNIT-5: Closed loop controllers (Hours-8)

P,I, PID Controllers, Digital Controllers, Program Logic Controllers, Input/output & Communication systems, Fault findings.

TEXT BOOKS

1. Mechatronics: Bolton, W., Longman
2. W. de Silva, Farbod Khoshnoud, Maoqing Li, Saman K. Halgamuge , " Mechatrinics –Fundamentals and Application" , CRC Press

REFERENCE BOOKS

1. Introduction to Mechatronics: D.G. Alciatore & Michael B. Histand; Tata Mc Graw Hill
2.A.K.Singh , " Mechatronics " , Vayu Education of India
3. W. de Silva, Farbod Khoshnoud, Maoqing Li, Saman K. Halgamuge, "Mechatronics " , Boca Raton

Course outcomes:
CO1. To inculcate the evolution of Mechatronics Engineering from historical point of view.
CO2. To understand the changes in technology in different ages like stone age to modern age of technology
CO3. To understand the latest innovations and inventions in the field of Mechatronics Engineering
CO4. To understand the recent trends in the field of automation and robotics and explore various aspects of innovation and inventions
CO5. To understand the PID Controllers, Digital Controllers, Program Logic Controllers

Mechatronics **ME-306**	**Course outcomes**	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
	CO1	1	2	2	2	2			1	1	2	3	1		
	CO2	1	1					2	2	2	1	3	2		
	CO3	2	1	2	2	1	2	2			1	3	3	2	
	CO4	1	2	1				1	2	2	1	2	3	3	
	CO5	1	1	2	2	2	2	2				2	2		

Course code	Course title	L	T	P	Credits
ME-308	**MACHINE DESIGN**	3	0	0	3

Course objective:
1. The objectives of this course are to: identify the forces involved in mechanisms and formulate equations for rigid body dynamics.
2. Interpret the cause and effects of unbalancing in machines relate forces and torque required to overcome.
3. The objectives of this course are to: identify the forces involved in mechanisms and formulate equations for rigid body dynamics.
.4. Study the friction in mechanical systems.

UNIT-1: Introduction

Definition, Design requirements of machine elements, Design procedure, Standards in design, Selection of preferred sizes, Indian Standards designation of carbon & alloy steels, Selection of materials for static and fatigue loads. Design for Static Load Modes of failure, Factor of safety, Principal stresses, Stresses due to bending and torsion, Theory of failure. **(Hours-8)**

UNIT-2: Design for Fluctuating Loads

Cyclic stresses, Fatigue and endurance limit, Stress concentration factor,Stress concentration factor for various machine parts, Notch sensitivity, Design for finite and infinite life, Soderberg, Goodman & Gerber criteria. **(Hours-8)**

UNIT-3 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 **(Hours-8)**

UNIT-4: Mechanical Springs

Types, Material for helical springs, End connections for compression and tension helical springs, Stresses and deflection of helical springs of circular wire, Design of helical springs subjected to static and fatigue loading. **(Hours-8)**

UNIT-5: Keys and Couplings

Types of keys, splines, Selection of square & flat keys, Strength of sunk key, Couplings, Design of rigid and flexible couplings. Power Screws Forms of threads, multiple threads, Efficiency of square threads, Trapezoidal threads, Stresses in screws, Design of screw jack **(Hours-8)**

TEXT BOOKS

1. Design of Machine Elements,V.B. Bhandari, Tata McGraw Hill Co. 2. Machine Design-Sharma and Agrawal, S.K. Kataria& Sons.

REFERENCE BOOKS:

1. Machine Design, U C Jindal, Pearson Eductaion.

2. Design of Machine Elements, Sharma and Purohit, PHI.

3. Design of Machine Elements-M.F. Spott, Pearson Eductaion

4. Machine Design-Maleev and Hartman, CBS Publishers.

5. Mechanical Engineering Design, 9e – Joseph E. Shigely, McGraw Hill Education.

Course outcomes:
CO1.Compute the stress acting on various machine elements CO2.Compute the dimensions, stress requirements of shaft and couplings based on various load conditions CO3.Summarize about temporary and permanent joints based on application requirements CO4.Compute the dimensions of the energy storing devices for specific applications CO5.Predict appropriate bearing, from the standard catalog for varied application.

MACHINE DESIGN ME-308	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2	1	2		1	2	3	1		1	3	1		
	CO2	2	2		1		2		1		1	3	2		2

	CO3	2		2			2	1		2	1	3	1		
	CO4	2		1	2		1		1	1		2	1		2
	CO5	2	1		2		1	3		1		2	2		

Course code	Course title	L	T	P	Credits
ME-352	**CAD/CAM Lab**	0	0	2	1

Course Objectives:
1. The objective of this lab to introduce computerized manufacturing systems to the students. To expose the students to the techniques of CNC programming and cutting tool pathgeneration through CNC simulation software by using G-Codes and M-codes

List of Experiments **Total number of hours 13**

1. Modeling and Simulation of Computer Integrated Manufacturing System
2. Modelling, Offline Manual Part Programming and Simulation of the operation of a 3 axis CNC Milling Machine
3. Programming and operation of a 3 axis CNC Miling Machine
4. CAD/CAM based Part Programming and operation of a 3 axis CNC Milling Machine
5. Modelling, offline programming and simulation of a 5-Axis Robot manipulator
6. Programming and operation of a 5-Axis Robot manipulator
7. Machine vision-based quality control
8. Remote Monitoring and Operation of a Computer Integrated Manufacturing System

Note- The initial lab period is of introduction part for the concerned lab. The second period will be of conduct on model experimentation.

Course outcomes:

CO1. Design and validate technological solutions to defined problems and communicate clearly and effectively for the practical application of their work.
CO2. Review and document the knowledge developed by scholarly predecessors and critically assess the relevant technological issues
CO3. Students will be able to apply knowledge about Computer Aided Quality control and ProcessPlanning Control
CO4. Students will be able to Design Flexible manufacturing cell after carrying out Grouptechnology study and finally creating FMS
CO5. To develop habit of individual critical thinking in analyzing a complex problem in thecomputer aided designing, manufacturing and optimization.

CAD/CAM Lab ME-352	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO	PSO1	PSO2
	CO1	2		2	2	1			2		1	2	2	1	
	CO2					1	1	2	2				1		
	CO3	2					1				1	2	1	2	
	CO4	1		1	2		1		1	2	3		2		
	CO5	2	1		2		1					1	1		

Course code	Course title	L	T	P	Credits
ME- 354	**Theory of Machine Lab**	0	0	2	1

Course objective:

1. To Study and acquire knowledge on differential gear box, torque relation for gyroscope, Steering Mechanisms.
2. To introduce the approaches and mathematical models used in kinematic and dynamic analysis of machinery.
3. To give basic knowledge on kinematic and dynamic design of machinery.
4. To give basic knowledge on mechanical vibrations

List of Experiments: **Total number of hours 13**

2. To study inversions of four bars chain and slider crank mechanism and their practical applications.
3. To study Steering Mechanisms: Davis and Ackerman.
4. Study of quick return mechanism and its practical applications. Study of inversion of Double slider chain: Oldham Coupling, Scotch Yoke and Elliptical Trammel.
5. Study of various cam-follower arrangements.
6. To plot displacement v/s angle of rotation curve for various cams Study of various types of dynamometers, Brakes and Clutches.
7. Study of differential gear box.

8. To verify the torque relation for gyroscope.
9. To perform wheel balancing. To perform static and dynamic balancing on balancing set up.

Note- The initial lab period is of introduction part for the concerned lab. The second period will be of conduct on model experimentation.

Course outcomes:
CO1.Compute the gyroscopic couple in gyroscope and centrifugal force in various governors CO2. Distinguish the significance of the Scotch Yoke and Elliptical Trammel. CO3. Compute the parameters of wheel balancing CO4. Discuss the kinematic working models of various mechanisms and Double slider chain. CO5. Compute the static and dynamic balancing

Theory of Machine Lab ME- 354	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2				1					1	2	2		
	CO2					1	1	2			2	3	1		
	CO3	2		3			1	1		2	1	2	1	1	
	CO4	1		1	2		1		1	2	3		2		
	CO5	2	1		2		1	3		2		1	1	1	

Course code	Course title	L	T	P	Credits
ME-356	Mechatronics and automation lab	0	0	2	1

Course Objectives:
1. To know the method of programming the microprocessor and also the design, modeling & analysis of basic electrical, hydraulic & pneumatic Systems which enable the students to understand the concept of mechatronics.

LIST OF EXPERIMENTS **Total number of hours 13**

1. Assembly language programming of 8085 – Addition – Subtraction – Multiplication – Division – Sorting – Code Conversion.
2. Stepper motor interface.
3. Traffic light interface.

4. Speed control of DC motor.
5. Study of various types of transducers.
6. Study of hydraulic, pneumatic and electro-pneumatic circuits.
7. Modelling and analysis of basic hydraulic, pneumatic and electrical circuits using Software.
8. Study of PLC and its applications.
9. Study of image processing technique.

Note- The initial lab period is of introduction part for the concerned lab. The second period will be of conduct on model experimentation.

Course outcomes:
CO1. Discuss Assembly language programming of 8085 CO2. Distinguish the significance of Stepper motor and Traffic light interface. CO3. Compute the parameters of Speed control of DC motor. CO4. Discuss the working of hydraulic, pneumatic and electro-pneumatic circuits. CO5. Explain the significance of image processing technique.

Mechatronics and automation lab **ME-356**	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2		2		1			2		1	2	2		
	CO2		2			1					2	3	1		
	CO3	2	2	3			1	1		2	1	2	1		
	CO4	1					1		1	2	3		2		
	CO5	2	1		2				2	2		1	1		

VII semester

Course code	Course title	L	T	P	Credits
MG-405	Operation Research	3	0	0	3

Course Objectives:
The course aims at building capabilities in the students for analyzing different situations in the industrial/ business scenario involving limited resources and finding the optimal solution within constraints.

UNIT1- Nature and development of Operations Research: some mathematical preliminaries, OR and managerial decision making, OR applications in industrial and non-industrial fields.

UNIT 2-Linear Optimization Models: formulation of linear programming problem, graphical solution, sensitivity analysis in graphical solution, comparison of graphical and simplex algorithm, simplex algorithm, computational procedure in simplex, penalty method, two phase method, degeneracy, duality and its concept, application of LP model to product mix and production scheduling problems.

UNIT 3- The transportation model: solution methods, balanced and unbalanced problems, Vogel's approximation method, degeneracy in transportation problems. Assignment problem, methods for solving assignment problems. The traveling salesman problem. Numericals on transportation, assignment and traveling salesman method. Computer algorithms for solution to LP problems.
Dynamic programming problems: model formulation, computational procedures, solution in different stages. Decision making under conditions of risk, assumed certainty.

UNIT 4- Waiting line models: queuing systems and concepts, various types of queuing situations, single server queues with poison arrivals and exponential service times, finite queue length model, industrial applications of queuing theory.

UNIT 5- Simulation: advantages and limitations of the simulation technique: generation of random numbers, Monte-Carlo simulation, computer-aided simulation, applications in maintenance and inventory management.

Refrence Books.

1. Taha,H A, "Operations Research - An Introduction", Sixth Edition, Prentice Hall of India Private Limited, N. Delhi, 2004.
2. Hillier, F S, "Operations Research", First Indian Edition, CBS Publishers & Distributors, Delhi, 1994.
3. Wagner H M, "Principles of Operations Research", Second Edition, Prentice Hall of India Private Limited, New Delhi, 2003.
4. Mustafi C K, "Operations Research", Third Edition, New Age International Pvt. Ltd., New Delhi, 1996.
5. Gupta P K, & Hira D.S., "Operations Research", Third Edition, S Chand & Company Ltd., New Delhi, 2005.

Course outcomes:
CO1. Solve the mathematical model manually as well as using soft resources/software such as solver etc.
CO2. Understand variety of problems such as assignment, transportation, travelling salesman etc.
CO3. Solve the problems mentioned in point 4 using linear programming approach using software
CO4. Develop linear programming (LP) models for shortest path, maximum flow, minimal spanning tree, critical path, minimum cost flow, and transshipment problems.
CO5. Solve the problems using special solution algorithms.

Operation Research MG 405	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2		2		1			2		1	2	2		
	CO2		2			1					2	3	1		
	CO3	2	2	3			1	1		2	1	2	1		
	CO4	1					1		1	2	3		2		
	CO5	2	1		2				2	2		1	1		

Course code	Course title	L	T	P	Credits
PEP 401	Professional Skills	1	0	2	2

Course objective:

1. Actively & effectively participate in group discussions towards gainful employment
2. Identify career opportunities (offline & online) in consideration of their own potentialand aspirations

Module 1 – Preparing for the Transition – 12 hours

- ***Social & Cultural Graces***
  - Meaning, Social Grace at Work, Acquiring Social Graces.
  - Need for etiquette (impression, image, earn respect, appreciation, etc)
  - Aspects of social and cultural/corporate etiquette in promoting teamwork
  - Importance of time, place, propriety and adaptability to diverse cultures
- ***Table Manners***
  - Meaning – Table Etiquettes in Multicultural Environment
  - Dos and Don'ts of Table Etiquettes.
- ***Dress Code & Personal Grooming***

- Dress Code for selected Occasions
- Dress Code for an Interview.

- ***Trust & Collaboration***
  - Importance of trust in creating a collaborative team
  - Agree to Disagree and Disagree to Agree – Spirit of Team work
  - Understanding fear of being judged and strategies to overcome fear
- ***Brainstorming***
  - Use of group and individual brainstorming techniques to promote idea generation.
  - Learning and showcasing the principles of documentation of team session outcomes

Module 2: Career Skills – 12 hours

- Resume & CV Writing: Difference between a CV, Resume and Bio data
- Essential components of a good resume
- Group Discussion Skills
- Exploring Career Opportunities
- Personal Branding & Digital Literacy
- Oral Presentations
- Presentation Aids and their usage

- ***Interview Skills***
  - Definition, Types of skills – Employer Expectations –Planning for the Interview –

Interview Questions Critical Interview Questions

- Meaning and types of interviews (F2F, telephonic, video, etc.)
- Dress Code, Background Research, Do's and Don'ts
- Situation, Task, Approach and Response (STAR Approach) for facing an
- interview
- Interview procedure (opening, listening skills, closure, etc.)
- Important questions generally asked in a job interview (open and closed endedquestions)

- ***Exploring Career Opportunities***

- Exploring Career Opportunities: The Process of getting hired
- Personal Branding
- Importance of digital literacy
- Knowledge about the world of work, requirements of jobs including self-employment.
- Sources of career information
- Preparing for a career based on their potentials and availability of opportunities

REFERENCE BOOKS:

- 10 Things Employers Want You to Learn in College, Revised: The Skills You Need to Succeedby Bill Coplin July 31, 2012
- Self-Esteem by Dr. Joe Rubino
- 73 Rules of Influencing the Interview by Chris Delaney, July 2012
- Developing Transferable Skills: Enhancing Your Research and Employment Potential by PamDenicolo and Julie Reeves Dec 2013

Course outcomes:

1. Prepare their Resume/CV in an appropriate template without grammatical and othererrors using proper syntax
2. Demonstrate understanding of Cross-Cultural communication and requisites
3. Participate in a simulated interview to gain insight on interviewing skills by analysing the common errors generally made by candidates in an interview
4. Demonstrate personal grooming skills
5. Demonstrate digital literacy and personal branding.

	Course outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
Professional Skills PEP-401	CO1	2				1					1		1		
	CO2	1			1					2			1		

CO3	1			1				1		1		1		
CO4	2		1			1				1				
CO5	2			1					1		2	1		

Semester VIII

Course code	Course title	L	T	P	Credits
MG-408	Economic life cycle concept	3	0	0	3

Course Objectives:
The purpose of this course is to help students learn the fundamentals of economics and they can apply these concepts to their lives and to the world in which they live.

UNIT1- National Income Nature and scope of Macro Economics, National income- Concepts and measurement of national income, Cyclic flow of income and expenditure, National income accounting.

UNIT 2-Output , Employment and consumption The classical theory of employment, Say's law of market, Keynes objection to the classical theory; Keynesian theory of output and employment, The principles of effective demand, Consumption function- average and marginal propensity to consume

UNIT 3- Investment, Saving and rate of interest Investment function- Autonomous and Induced Investment, Marginal efficiency of capital, Saving function, Saving and Investment equality. The concept of multiplier, investment multiplier. Classical, Neo- Classical and Keynesian theories of interest..

UNIT 4- Trade Cycles Nature and characteristics of trade cycle; Hawtrey's monetary theory, Hayek's over-investment theory; Keynes view of trade cycle. The concept of accelerator, Samuelson and Hicks multiplier-accelerator interaction model. Control of trade cycle

UNIT 5- Economic Growth Sources of growth, Growth models- Harrod and Domar. Neo classical growth models-Solow. Technical progress model- Kaldor's model of economic growth..

Refrence Books.

1. Jhingan M.L.- Macro Economics
2. Gupta, S.B. (1994), Monetary Economics, S. Chand and Co., Delhi.
3. Shapiro, E. (1996), Macroeconomics Analysis, Galgotia Publications, New Delhi.
4. Vaish, M.C. Macro Economics..

Course outcomes:
CO1. Explain the concepts of Macroeconomics and its interrelations with Microeconomics. CO2. Associate the current economic phenomenon with existing theory and put their views on

contemporary economic issues.
CO3. Apply the principle of Macroeconomics in explaining the behaviour of Macroeconomic variables at national as well as global level.
CO4. Extend the concepts of Macroeconomics in unfolding the dynamics of energy sectors.

Economic life cycle concept MG-408	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2		2		1			2		1	2	2		
	CO2		2			1					2	3	1		
	CO3	2	2	3			1	1		2	1	2	1		
	CO4	1					1		1	2	3		2		

OPEN ELECTIVE

Course code	Course title	L	T	P	Credits
ME-431A	Refrigeration and air conditioning	3	0	0	3

Course objective:

The course is designed to give fundamental knowledge of types of refrigeration, refrigeration cycles, refrigerants and their behavior under various conditions, air conditioning load calculation and designing of components of air distribution system

UNIT-1: Introduction and Refrigerant: Brief history and need of refrigeration and air conditioning, methods of producing cooling, ton of refrigeration, coefficient of performance, types and application of refrigeration and air condensing systems, Recapitulation of desirable properties of refrigerants, secondary refrigerants, future industrial refrigerants

UNIT-2: Air refrigeration: Aircraft refrigeration, working and analysis of Simple, Bootstrap, Reduced ambient and Regenerative air refrigeration systems

UNIT-3: Compound Compression VCR system: Multiple evaporators with back pressure valves and with multiple expansion valves without flash inter cooling, analysis of two evaporators with flash intercooler and individual expansion valve and multiple expansion valve, cascade refrigeration system

UNIT-4: Absorption refrigeration system: Practical H2O -NH3 cycle, LiBr – H2O system and its working, h-x diagram and simple calculation of various process like adiabatic mixing and mixing with heat transfer, throttling

UNIT-5: Refrigeration system components: Types, construction, working, comparison and

selection of compressors, condensers, expansion devices and evaporators; refrigeration piping accessories, evacuation and charging of refrigerant, properties and classification of thermal insulation

TEXT BOOKS

1. Refrigeration and Air Conditioning by C P Arora, McGraw-Hill India Publishing Ltd.
2. Refrigeration and Air-conditioning by Ramesh Arora , Prentice Hall of India

REFERENCE BOOKS:

1. Refrigeration and Air Conditioning by Manohar Prasad, New Age International Publisher
2. ASHRAE Handbook – Fundamentals 2017, ASHRAE
3. Automobile Air conditioning by Crouse and Anglin, McGraw Hill Publications

Course outcomes:
CO1. To select proper refrigerant for various applications and make basic calculations of aircraft refrigeration. CO2. To analyze multi-evaporator systems and simple vapor absorption systems. CO3. To explain construction and working of different refrigeration system components. CO4. To solve air-conditioning load calculations for buildings and automobiles. CO5. To select proper air-conditioning system for various applications and construct duct layout for the systems.

Refrigeration and air conditioning ME-431A	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2				1					1		1		
	CO2	1			1					2			1		
	CO3	1			1				1		1		1		
	CO4	2		1			1				1				
	CO5	2			1					1		2	1		

Course code	Course title	L	T	P	Credits
ME-431B	Optimization technique	3	0	0	3

Course objective:
1. The students will try to learn optimization techniques based upon the fundamentals of engineering mathematics (minimization and Maximization of objective function).

UNIT-1: Introduction to Classical Optimization Techniques

Statement of an Optimization problem – design vector – design constraints – constraint surface – objective function – objective function surfaces – classification of Optimization problems.

UNIT-2: Linear Programming

Various definitions, statements of basic theorems and properties, Advantages, Limitations and Application areas of Linear Programming, Graphical method of Linear Programming problem.

Simplex Method **–**Phase I and Phase II of the Simplex Method, The Revised Simplex method, Primal and Dual Simplex Method, Big –M method.

UNIT-3: Transportation Problem

Finding initial basic feasible solution by north – west corner rule, least cost method and Vogel's approximation method – testing for optimality of balanced transportation problems. (Including assignment and travelling salesman problems) (No degeneracy problems)

Queuing-Queuing Models : Essential features of queuing systems, operating characteristics of queuing system, probability distribution in queuing systems, classification of queuing models,

UNIT-4: Dynamic Programming

Dynamic programming multistage decision processes – types – concept of sub optimization and the principle of optimality – computational procedure in dynamic programming – examples illustrating the calculus method of solution - examples illustrating the tabular method of solution.

UNIT-5: Simulation Modeling

Introduction, Definition and types, Limitations, Various phases of modeling, Monte Carlo method, Applications, advantages and limitations of simulation

TEXT BOOKS

1. Engineering optimization: Theory and practice"-by S.S.Rao, New Age International (P) Limited.

2. Operations Research: An Introduction" by H A Taha, 5th Edition, Macmillan, New York.

3. Operations Research by NVR Naidu, G Rajendra, T Krishna Rao, I K International Publishing house, New Delhi.

REFERENCE BOOKS:

1. Optimization Methods in Operations Research and systems Analysis" – by K.V. Mittal and C. Mohan, New Age, International (P) Limited, Publishers

2. Operations Research – by S.D.Sharma, KedarnathRamanath& Co

3. Linear programming, G. Hadley, Narosa Publishing House, New Delhi.

4. Industrial Engineering and Production Management, M. Mahajan, DhanpatRai& co

Course outcomes:
CO1.Understand the overview of optimization techniques, concepts of design space, constraint surfaces and objective function. CO2. Review differential calculus in finding the maxima and minima of functions of several variables. CO3. Formulate real-life problems with Linear Programming. CO4. Solve the Linear Programming models using graphical and simplex methods. CO5. Formulate real-life transportation, assignment and travelling salesman problems to find the optimum solution using transportation algorithms

Optimization technique ME-431B		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	3				2					1		1		
	CO2	3			1					1			1		
	CO3	3		1	2				1		1		1		
	CO4	3					2				1				
	CO5	1				2			2			2			

Course code	Course title	L	T	P	Credits
ME-432A	Industrial robot	3	0	0	3

Course objective:

1. The goal of the course is to familiarize the students with the concepts and techniques in robotic engineering, manipulator kinematics, dynamics and control, chose, and incorporate robotic technology in engineering systems.
2. Make the students acquainted with the theoretical aspects of Robotics
3. Enable the students to acquire practical experience in the field of Robotics through design projects and case studies.
4. Make the students to understand the importance of robots in various fields of engineering.
5. Expose the students to various robots and their operational details.

UNIT-1: Introduction: Automation and Robotics – An over view of Robotics – present and future applications. Components of the Industrial Robotics: common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, Design of end effectors, Precision of Movement: Resolution, Accuracy and Repeatability, Speed of Response and Load Carrying Capacity

UNIT-2: Motion Analysis: Basic Rotation Matrices, Equivalent Axis and Angle, Euler Angles, Composite Rotation Matrices. Homogeneous transformations as applicable to rotation and translation – problems. Manipulator Kinematics-H notation-H method of Assignment of frames-H Transformation Matrix, joint coordinates and world coordinates, Forward and inverse kinematics – problems on Industrial Robotic Manipulators.

UNIT-3: Differential transformation of manipulators, Jacobians – problems. Dynamics: Lagrange – Euler and Newton – Euler formations – Problems. Trajectory planning and avoidance of obstacles, path planning, Slew motion, joint interpolated motion straight line motion.

UNIT-4: Robot actuators and Feedback components: Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors, comparison of Actuators, Feedback components: position sensors – potentiometers, resolvers, encoders – Velocity sensors, Tactile and Range sensors, Force and Torque sensors – End Effectors and Tools

UNIT-5: Robot Application in Manufacturing: Material Transfer – Material handling, loading and unloading- Processing – spot and continuous arc welding & spray painting – Assembly and Inspection. Robotic Programming Methods – Languages: Lead Through Programming, Textual Robotic Languages such as APT, MCL.

TEXT BOOKS

1. Robot Dynamics and Controls / Spony and Vidyasagar / John Wiley
2. Robot Analysis and control / Asada, Slotine / Wiley Inter-Science Robotics – Fu et al / TMH Publications.

REFERENCE BOOKS:

1. Industrial Robotics / Groover M P /Mc Graw Hill
2. Introduction to Industrial Robotics / Ramachandran Nagarajan / Pearson

Course outcomes:
CO1. At the end of the course, the student will be able to understand the basic components of robots. Differentiate types of robots and robot grippers. CO2. Model forward and inverse kinematics of robot manipulators. CO3. Analyze forces in links and joints of a robot. CO4.Programme a robot to perform tasks in industrial applications. CO5. Design intelligent robots using sensors.

Industrial robot ME-432A	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2				2					1		1		
	CO2				3					1			1		
	CO3	3		2	1				2		1		1		
	CO4	1						1							
	CO5	2	3					1						3	

Course code	Course title	L	T	P	Credits
ME-432B	Automotive maintenance and service	3	0	0	3

Course objective:
To present a problem oriented in depth knowledge of Vehicle maintenance. • To address the underlying concepts and methods behind Vehicle maintenance

UNIT-1: Vehicular Maintenance Practices: Types of maintenance schedules (daily, weekly and monthly) in respect of the Scheduled maintenance chart shown in service book of a vehicle, Break down, Preventive, Predictive maintenance practices, maintaining interior cleaning, maintaining exterior cleaning.

UNIT-2: ENGINE MAINTENANCE – REPAIR AND OVERHAULING Dismantling of engine components and cleaning, cleaning methods, visual and dimensional inspections, minor and major reconditioning of various components, reconditioning methods, engine assembly, special tools used for maintenance overhauling, engine tune up, including modern engines**.**

UNIT-3: CHASSIS MAINTENANCE - REPAIR AND OVERHAULING Mechanical and automobile clutch, fluid flywheel, torque converter, automatic transmission and gear box, servicing and maintenance. Maintenance servicing of propeller shaft and differential system. Maintenance servicing of suspension systems. Brake systems, types and servicing techniques. Steering systems, overhauling and maintenance. Wheel alignment, computerized alignment and wheel balancing.

UNIT-4: ELECTRICAL AND ELECTRONIC SYSTEM MAINTENANCE – SERVICING AND REPAIRS Testing methods for checking electrical and electronic components, checking battery, starter motor, charging systems, DC generator and alternator, ignitions system, lighting systems. Fault diagnosis and maintenance of modern electronic controls, checking and servicing of dash board instruments.

UNIT-5: MAINTENANCE OF FUEL SYSTEM, COOLING SYSTEMS, LUBRICATION SYSTEM AND VECHICLE BODY 8 Servicing and maintenance of fuel system of different types of vehicles, calibration and tuning of engine for optimum fuel supply. Cooling systems, water pump, radiator, thermostat, anticorrosion and antifreeze additives. Lubrication maintenance, lubricating oil changing, greasing of parts. Vehicle body maintenance, minor and major repairs. Door locks and window glass actuating system maintenance.

TEXT BOOKS

1. Automotive mechanics by Crouse,TMH
2. Automobile system by Anil Chikara. o K.K.Ramlingan
3. Automobile Engineering, SciTech Publication

REFERENCE BOOKS:

1. Joseph Heitner, Automechanics, East West Press.
2. Pattern and Donald, Automotive Service Basics, Pearson Publications.
3. Vehicle Service book

Course outcomes:
CO1. The student can identify different areas of Vehicle maintenance.
CO2. Can find the applications of all the areas in day to day life.
CO3. Can find the applications of all the engines.
CO4. Can find the applications of all the areas of operational ability.
CO5. Can Identify the major and minor faults.

Automotive maintenance service ME-432B	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2				1					1		1		
	CO2	3			2					1			1		
	CO3	3		2	1				2		1		1		
	CO4	2					1				1				
	CO5	1			2					2		1	1		

PROGRAMME ELECTIVE

ELECTIVE I

Course code	Course title	L	T	P	Credits
ME-321	Sustainable energy engineering	3	0	0	3

Course objective:
1. To enable the students to develop managerial skills to assess feasibility of alternative approaches and drive strategies regarding Wind and Alternative Sources

UNIT-I

Introduction to Energy:

Definition and units of energy, power, Forms of energy, Conservation of energy, second law of thermodynamics, Energy flow diagram to the earth. Origin and time scale of fossil fuels, Conventional energy sources, Role of energy in economic development and social transformation. Classification of energy resources, Conventional-Nonconventional, Renewable-Nonrenewable, Green energy, Clean energy (Definitions and examples), Green footprint, Carbon footprint, Ecological footprint concepts,

UNIT-II

Indian Energy Scene:

Energy resources available in India, urban and rural energy consumption, energy

consumption pattern and its variation as a function of time, nuclear energy - promise and future, energy as a factor limiting growth, need for use of new and renewable energysources. National Green Tribunal (NGT) act, NGT activities.

UNIT-III

Solar constant

Solar Radiation spectrum, Classification of Solar cells. First generation ñ Single crystalline, Poly crystalline, Second Generation ñ Thin film, CdS, CIGs, Third Generation ñ Polymer based, DSSC, Parovskites, Hybrid, Quantum Dots, Multi Junction Tandem cells. (And/Or) Organic, Inorganic and Hybrid cells. Key elements of Silicon Solar cell, PV Solar cell, Module, panel and array. Solar thermal systems types, applications of SolarPV and Solar Thermal systems.

UNIT-IV

Geothermal energy:

Introduction ñ Estimates of Geothermal Power ñ Nature of geothermal fields ñ Geothermal resources ñ Hydrothermal (convective) Resources Geo pressuredresources

UNIT V

Ocean Energy: Introduction, Principle of ocean thermal energy conversion (OTEC), Tidal power generation, Tidal energy technologies, Energy from waves, Wave energy conversion, Wave energy technologies, advantages anddisadvantages.

Text book:

1. Solar Energy Principles, Thermal Collection &Storage, S.P.Sukhatme: Tata McGraw HillPub., NewDelhi.
2. Non-Conventional Energy Sources, G.D.Rai, NewDelhi.
3. Renewable Energy, power for a sustainable future, Godfrey Boyle,2004,
4. The Generation of electricity by wind, E.W.Golding.
5. Non-Conventional Energy Resources by B.H. Khan, Tata McGraw Hill Pub.,2009.

References:

1. Fundamentals of Renewable Energy Resources by G.N.Tiwari, M.K.Ghosal, Narosa Pub.,2007.
2. Non-Conventional Energy Resources by B.H. Khan, Tata McGraw Hill Pub., 2009. (Ch:6)

Course outcomes:
CO1. Understand the need of energy conversion and the various methods of energy storage
CO2. Explain the field applications of solar energy
CO3. Identify Winds energy as alternate form of energy and to know how it can be tapped
CO4. Explain bio gas generation and its impact on environment
CO5. Understand the Geothermal &Tidal energy, its mechanism of production and its applications

Sustainable energy engineering ME-321	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2				1					1		1		
	CO2	3			2					1			1		
	CO3	3		2	1				2		1		1		
	CO4	2					1				1				
	CO5	1			2					2		1	1		

Course Code	**Course title**	**L**	**T**	**P**	**Credits**
MEDP 321	**FUNDAMENTALS OF 3 D PRINTING**	**3**	**0**	**0**	**3**

Course Objectives	
1.	To Know the importance of 3D printing in Manufacturing
2.	To know the different 3D Printing Technologies
3.	To select a suitable material for 3D Printing
4.	To observe the different methods for Post-processing of 3D Printing parts
5.	To Understand the applications of 3D Printing in Automobile, Aerospace, Bio-medical etc.

UNIT-1: Introduction

Introduction, Prototyping fundamentals, Historical development, Advantages of AMT, commonly used terms, process chain, 3D modelling, Data Conversion, and transmission, Checking and preparing, Building, Post processing, RP data formats, Classification of AMT process, Applications to various fields

UNIT-2: Liquid based systems

Stereo lithography apparatus (SLA): Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. Solid ground curing (SGC): Models and specifications, process, working, principle, applications, advantages and disadvantages, case studies.

UNIT-3: Solid based systems

Laminated object manufacturing(LOM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies. Fu sed Deposition Modeling (FDM): Models and specifications, Process, Working principle, Applications,

Advantages and disadvantages, Case studies, practical demonstration

UNIT-4: Powder Based Systems

Selective laser sintering (SLS): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Three-dimensional printing (3DP): Models and specification, process, working principle, applications, advantages and disadvantages, case studies.

UNIT-5: APPLICATIONS

Aerospace, Automotive, Biomedical Applications of AM. Product Development, Commercialization, Trends and Future Directions in Additive Manufacturing.

TEXT BOOKS:

1. Ian Gibson, David W. Rosen and Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing, Springer, 2010.
2. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: Principles and applications, 3rd Edition, World Scientific, 2010.

REFERENCE BOOKS:

1. Hopkinson, Hague, Dickens, Rapid Manufacturing: An Industrial Revolution for the Digital Age. Wiley, 2005.
2. Gibson, Advanced Manufacturing Technologies for Medical Applications. Wiley, 2005
3. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.
4. J.D. Majumdar and I. Manna, Laser-assisted fabrication of materials, Springer Series in Material Science, 2013.
5. L. Lu, J. Fuh and Y. S. Wong, Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press, 2001.
6. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM) processes of titanium alloy, lnTech, 2012.

Course outcomes:
CO1. Importance of 3D printing in Manufacturing CO2. Different 3D Printing Technologies CO3. Select suitable materials for 3D Printing CO4 Different methods for Post-processing of 3D Printing parts CO5. Applications of 3D Printing in Automobile, Aerospace, Bio-medical etc.

FUNDAMENTALS OF 3 D PRINTING MEDP 321	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2	1	2		1	2	2	1		1	3	1		
	CO2	2	2		1		2		1		1	3	2		

CO3	2		1			2	1		2	1	3	1		
CO4	1						1							
CO5									1					

Course Code	Course Title	L	T	P	Credit
MEEV-321	**Fundamentals of Electric & Hybrid Vehicles**	3	0	0	3

Course Objective:

1. To understand the concept of electric vehicles.
2. To study about the motors & drives for electric vehicles.
3. To understand the electronics and sensors in electric vehicles.
4. To understand the concept of hybrid vehicles.
5. To study about fuel cell for electric vehicles.

UNIT - I Introduction to Electric Vehicles

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

UNIT - II Electric Vehicle Motors

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

UNIT - III Electronics and Sensor-less control in EV

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

UNIT - IV Hybrid Vehicles

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

UNIT - V Fuel Cells for Electric vehicles

Fuel cell – Introduction, Technologies & Types, Obstacles. Operation principles, Potential

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

TEXT BOOK

1. Jack Erjavec and Jeff Arias, "Hybrid, Electric and Fuel Cell Vehicles", Cengage Learning, 2012.
2. Jack Erjavec and Jeff Arias, "Alternative Fuel Technology – Electric, Hybrid and Fuel Cell Vehicles", Cengage Learning Pvt. Ltd., New Delhi, 2007
3. Mehrdad Ehsani, Yimin Gao, sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2009.

REFERENCES

1. Hybrid Electric Vehicle System Modeling and Control - Wei Liu, General Motors, USA, John Wiley & Sons, Inc., 2017.
2. Hybrid Electric Vehicles – Teresa Donateo, Published by ExLi4EvA, 2017.
3. Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure and the Market Gianfranco Pistoia Consultant, Rome, Italy, Elsevier Publications, 2017.
4. Hybrid, Electric & Fuel-Cell Vehicles Jack Erjavec, Delmar, Cengage Learning.

Course Outcome:
1. Describe about working principle of electric vehicles. 2. Explain the construction and working principle of various motors used in electric vehicles. 3. Understand about working principle of electronics and sensor less control in electric vehicles. 4. Describe the different types and working principle of hybrid vehicles. 5. Illustrate the various types and working principle of fuel cells.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	P08	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	1	2	1			1	2	2	1	1	1	2	2
CO2	2	3	1	2	1			2	2	2	2	2	2	2	2
CO3	3		2			1	1		1	3	1				
CO4	2	1	3	1		1	1	2	1	1	1	1	1	1	1
CO5	2	1	1	1		2		2	1	2	1	1	1	1	1

ELECTIVE II

Course code	Course title	L	T	P	Credits
ME-322	Power plant engineering	3	0	0	3

Course objective:

1. To introduce students to different aspects of power plant engineering.
2. To familiarize the students to the working of power plants based on different fuels.
3. To expose the students to the principles of safety and environmental issues

UNIT I COAL BASED THERMAL POWER PLANTS

Rankine cycle — improvisations, Layout of modern coal power plant, Super Critical Boilers, FBC Boilers, Turbines, Condensers, Steam & Heat rate, Subsystems of thermal power plants — Fuel and ash handling, Draught system, Feed water treatment. Binary Cycles and Cogeneration systems.

UNIT II DIESEL, GAS TURBINE AND COMBINED CYCLE POWER PLANTS

Otto, Diesel, Dual & Brayton Cycle — Analysis & Optimisation. Components of Diesel and Gas Turbine power plants. Combined Cycle Power Plants. Integrated Gasifier based Combined Cycle systems.

UNIT III NUCLEAR POWER PLANTS

Basics of Nuclear Engineering, Layout and subsystems of Nuclear Power Plants, Working of Nuclear Reactors : Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANada Deuterium- Uranium reactor (CANDU), Breeder, Gas Cooled and Liquid Metal Cooled Reactors. Safety measures for Nuclear Power plants.

UNIT IV POWER FROM RENEWABLE ENERGY

Hydro Electric Power Plants — Classification, Typical Layout and associated components including Turbines. Principle, Construction and working of Wind, Tidal, Solar Photo Voltaic (SPV), Solar Thermal, Geo Thermal, Biogas and Fuel Cell power systems.

UNIT V ENERGY, ECONOMIC AND ENVIRONMENTAL ISSUES OF POWER PLANTS

Power tariff types, Load distribution parameters, load curve, Comparison of site selection criteria, relative merits & demerits, Capital & Operating Cost of different power plants. Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants.

Text book:

1. Power Plant Engineering, P.K. Nag, Tata McGraw Hill.
2. Power Plant Engineering, F.T. Morse, Affiliated East-West Press Pvt. Ltd, New Delhi/Madras

References:

1. Power Plant Technology El-Vakil, McGraw Hill

Course outcomes:

CO1. Describe and analyze different types of sources and mathematical expressions related to thermodynamics and various terms and factors involved with power plant operation.
CO 2. Analyze the working and layout of steam power plants and the different systems comprising the plant and discuss about its economic and safety impacts
CO3. Combine concepts of previously learnt courses to define the working principle of diesel power plant, its layout, safety principles and compare it with plants of other types.
CO4. Describe the working principle and basic components of the nuclear power plant and the economic and safety principles involved with it.
CO5. Discuss the working principle and basic components of the hydro electric plants and the economic principles and safety precautions involved with it.

Power plant engineering ME-322	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2		2		1		2	2		1		1		
	CO2	3			2			1		1			1		
	CO3	3		2	1				2		1		1		
	CO4	2					1	1			1				
	CO5	1			2					2		1	1		

Course Code	**Course title**	**L**	**T**	**P**	**Credits**
MEDP 322	**ADDITIVE MANUFACTURING**	**3**	**0**	**0**	**3**

Course Objectives	
1.	Additive Manufacturing (AM) is an economically viable alternative to conventional manufacturing technologies for producing highly complex parts.
2.	The objective of the course is to impart fundamentals of additive manufacturing processes along with the various file formats, software tools, processes, techniques and applications.
3.	The main objective of this course is to acquaint students with the concept of AM, various AM technologies, selection of materials for AM, modeling of AM processes, and their applications in various fields.

UNIT-1: INTRODUCTION OF AM

Introduction to the Basic Principles of Additive Manufacturing, Additive Manufacturing Processes Extrusion, Beam Deposition.

UNIT-2: OPERATIONS IN AM

Jetting, Sheet Lamination, Direct-Write, Photopolymerization, Sintering, Powder Bed Fusion

UNIT-3: DESIGN/FABRICATION PROCESSES

Data Sources, Software Tools, File Formats, Model Repair and Validation, Pre- & Post-processing, Designing for Additive Manufacturing, Multiple Materials, Hybrids, Composite Materials, current and future directions.

UNIT-4: PROCESS AND MATERIAL

Process & Material Selection, Direct Digital Manufacturing and Distributed Manufacturing, Related Technologies: Mold-making, Rapid Tooling, Scanning.

UNIT-5: APPLICATIONS OF AM

Aerospace, Automotive, Biomedical Applications of AM. Product Development, Commercialization, Trends and Future Directions in Additive Manufacturing.

TEXT BOOKS:

1.Ian Gibson, David W. Rosen and Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing, Springer, 2010.

2.C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: Principles and applications, 3rd Edition, World Scientific, 2010.

REFERENCE BOOKS:

1. Hopkinson, Hague, Dickens, Rapid Manufacturing: An Industrial Revolution for the Digital Age. Wiley, 2005.
2. Gibson, Advanced Manufacturing Technologies for Medical Applications. Wiley, 2005
3. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.
4. J.D. Majumdar and I. Manna, Laser-assisted fabrication of materials, Springer Series in Material Science, 2013.
5. L. Lu, J. Fuh and Y. S. Wong, Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press, 2001.
6. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM) processes of titanium alloy, lnTech, 2012.

Course outcomes:
CO1. Importance of 3D printing in Manufacturing CO2. Different 3D Printing Technologies CO3. Select suitable materials for 3D Printing CO4 Different methods for Post-processing of 3D Printing parts CO5. Applications of 3D Printing in Automobile, Aerospace, Bio-medical etc.

ADDITIVE MANUFACTURING MEDP 322	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	1	1	2		1	1		1		1		1		
	CO2	2	1						1		1	1			
	CO3	2		1				1		1	1	1	1		
	CO4	1		2			1	1							
	CO5				2	2				1					

Course Code	Course Title	L	T	P	Credit
MEEV-322	**Electric vehicle technology**	3	0	0	3

Course objective:

1. Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2. Explain plug – in hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.

UNIT 1: **Vehicles:** Types of EVs, Hybrid Electric Drive-train, Tractive effort in normal driving, Energy consumption Concept of Hybrid Electric Drive Trains, Architecture of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel hybrid electric drive trains, Electric Propulsion unit, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, switched reluctance motor, Introduction to Energy Storage.

UNIT 2: **Requirements in Hybrid and Electric Vehicles:** Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system.

UNIT 3: Design of Hybrid Electric Vehicle and Plug-in Electric Vehicle, Energy Management Strategies, Automotive networking and communication, EV and EV charging standards, V2G, G2V, V2B, V2H.

UNIT 4: **Business:** E-mobility business, electrification challenges, Business- E-mobility business, electrification challenges, Connected

Mobility and Autonomous Mobility- case study E-mobility Indian Roadmap Perspective

UNIT 5 **Policy:** EVs in infrastructure system, integration of EVs in smart grid, social dimensions of EVs.

Text books:

- Emadi, A. (Ed.), Miller, J., Ehsani, M., "Vehicular Electric Power Systems" Boca Raton, CRC Press, 2003.
- Husain, I. "Electric and Hybrid Vehicles" Boca Raton, CRC Press, 2010.
- Larminie, James, and John Lowry, "Electric Vehicle Technology Explained" John Wiley and Sons, 2012

Course outcomes:
Co1. Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals. CO2 Analyse the use of different power electronics devices and electrical machines in hybrid electric vehicles. CO3 Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology CO 4 Interpret working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis and Energy Management strategies in HEVs.

Electric vehicle technology MEEV 322	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	3								1				2	
	CO2			2										2	
	CO3	2				2								1	
	CO4	1		2									2	2	

ELECTIVE III

Course code	Course title	L	T	P	Credits
ME-421	Mechanical Vibration	3	0	0	3

Course objective:

3. Formulate mathematical models of problems in vibrations using Newton's second law or energy principles,
4. Determine a complete solution to the modeled mechanical vibration problems
5. Obtain linear vibratory models of dynamic systems with changing complexities (SDOF, MDOF)

UNIT 1: **Fundamentals of Vibration**

Fundamental Aspects of Vibrations: Vibration, main causes, advantages and disadvantages; engineering applications of vibration and noise; vector method of representing harmonic motion; characteristics of vibration, harmonic analysis and beats phenomenon, work done by harmonic forces on harmonic motion; periodic, non- harmonic functions- Fourier series analysis; evaluation of coefficients of Fourier series; elements of vibratory system; lumped and distributed parameter systems. Undamped Free Vibrations: Derivation of differential equation of motion: the energy method, the method based on Newton's second law of motion, (Hours-8)

UNIT 2: **Free Vibration**

Damped Free Vibrations: Viscous damping: coefficient of damping; damping ratio; under damped, over damped and critically damped systems; logarithmic decrement; frequency of damped free vibration; Coulomb or dry friction damping; frequency, decay rate and comparison of viscous and Coulomb damping; solid and structural damping; slip or interfacial damping. (Hours-8)

UNIT 3: **Forced Damped Vibration**

Harmonically excited Vibration: One degree of freedom- forced harmonic vibration; vector representation of forces; excitation due to rotating and reciprocating unbalance; vibration Isolation, force and motion transmissibility; absolute and relative motion of mass (Seismic Instruments). Whirling Motion and Critical Speed : Whirling motion and Critical speed : Definitions and significance. (Hours-8)

UNIT 4: **Two Degree of Freedom**

Systems With Two Degrees of Freedom : Un-damped free vibration of 2 d.o.f and Principal modes of vibration; torsion vibrations; Forced, Un-damped vibrations with harmonic excitation ; Coordinate coupling; Dynamic vibration absorber; torsion Vibration Absorber; Pendulum type of dynamic vibration. (Hours-8)

UNIT 5: **Vibration of Continuous Systems**

Systems governed by wave equations - Vibration of strings - Vibration of rods - Euler's equation for beams - Effect of Rotary inertia and shear deformation.

(Hours-8)

TEXT BOOK

1. S.S. Rao, Mechanical Vibrations, 6th Edition, Pearson Education, 2016.

REFERENCE BOOK

1. Kelly SG, Mechanical Vibrations, Mcgraw Hill(India) Ltd., 2013.

Course outcomes:
CO1: Construct the equations of motion for free-body diagrams CO2: Compute the natural frequency for free and forced vibration of a single degree of freedom under damped or un-damped system CO3: Apply vibration absorbers and isolators for minimizing vibration in systems with two degree of freedom CO4: Compute natural frequencies of free and forced vibrations in systems with multi-degree of freedom CO5: Analyze properties of vibrating system using mathematical tools.

	Course outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
Mechanical Vibration ME 421	CO1	3								1				2	
	CO2			2										2	
	CO3	2				2								1	
	CO4	1		2									2	2	
	CO5				3									1	

Course Code	**Course title**	**L**	**T**	**P**	**Credits**
MEDP 421	**3 D Printing Process and Application**	**3**	**0**	**0**	**3**

Course Objectives	
1.	To Know the importance of 3D printing in Manufacturing
2.	To know the different 3D Printing Technologies

3.	To select a suitable material for 3D Printing
4.	To observe the different methods for Post-processing of 3D Printing parts
5.	To Understand the applications of 3D Printing in Automobile, Aerospace, Bio-medical etc.

UNIT-1: INTRODUCTION AND BASIC PRINCIPLES

3D Printing, Generic 3D Printing Process, Benefits of 3D Printing, Distinction Between 3D Printing and CNC Machining, Other Related Technologies
Development of 3D Printing Technology: Introduction, Computers, Computer-Aided Design Technology, Other Associated Technologies, The Use of Layers, Classification of 3D Printing Processes, Metal Systems, Hybrid Systems, Milestones in 3D Printing Development, 3D Printing around the World.

UNIT-2: 3D PRINTING PROCESS CHAIN & PHOTOPOLYMERIZATION PROCESSES

Eight Steps in Additive Manufacture, Variations from One 3D Printing Machine to Another, Metal Systems, Maintenance of Equipment, Materials Handling Issues, Design for 3D PRINTING.
Introduction to Photopolymerization Processes: Photopolymerization Materials, Reaction Rates, Vector Scan SL, SL Resin Curing Process, SL Scan Patterns, Vector Scan Micro stereolithography, Mask Projection Photopolymerization Technologies and Processes, Two-Photon SL.

UNIT-3: POWDER BED FUSION PROCESSES & EXTRUSION-BASED SYSTEMS

Powder Bed Fusion Processes: Introduction, SLS Process Description, Powder Handling, Approaches to Metal and Ceric Part Creation, Variants of Powder Bed Fusion Processes, Process Par3D Printingeters, Applied Energy Correlations and Scan Patterns, Typical Materials and Applications, Materials - Capabilities and Limitations.
Extrusion-Based Systems: Introduction, Basic Principles, Plotting and Path Control, Materials, Limitations of FDM, Bioextrusion, Other Systems.

UNIT-4: DESIGN, GUIDELINES FOR PROCESS SELECTION & SOFTWARE ISSUES

Design for 3D Printing - Design for Manufacturing and Assembly, Core DFM for 3D Printing Concepts and Objectives, 3D Printing Unique Capabilities, Exploring Design Freedoms, Design Tools for 3D Printing.
Guidelines for Process Selection - Selection Methods for a Part, Challenges of Selection, Preliminary Selection, Production Planning and Control.
Software Issues for 3D Printing - Preparation of CAD Models – the STL File, Problems with STL Files, STL File Manipulation, Beyond the STL File, Additional Software to Assist 3D Printing.

UNIT-5: MEDICAL APPLICATIONS & FUTURE DIRECTIONS FOR 3D PRINTING

Medical Applications for 3D Printing - Use of 3D Printing to Support Medical Applications,

Software Support for Medical Applications, Limitations of 3D Printing for Medical Applications, Further Development of Medical 3D Printing Applications.
Use of Multiple Materials in 3D Printing - Discrete Multiple Material Processes, Porous Multiple Material Processes, Blended Multiple Material Processes, Embedded Component 3D Printing, Commercial Applications Using Multiple Materials, Future Directions, Business Opportunities and Future Directions.

TEXT BOOKS:

3. Ian Gibson, David W. Rosen and Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing, Springer, 2010.
4. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: Principles and applications, 3rd Edition, World Scientific, 2010.

REFERENCE BOOKS:

7. Hopkinson, Hague, Dickens, Rapid Manufacturing: An Industrial Revolution for the Digital Age. Wiley, 2005.
8. Gibson, Advanced Manufacturing Technologies for Medical Applications. Wiley, 2005
9. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.
10. J.D. Majumdar and I. Manna, Laser-assisted fabrication of materials, Springer Series in Material Science, 2013.
11. L. Lu, J. Fuh and Y. S. Wong, Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press, 2001.
12. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM) processes of titanium alloy, lnTech, 2012.

Course outcomes:
CO1. Importance of 3D printing in Manufacturing CO2. Different 3D Printing Technologies CO3. Select suitable materials for 3D Printing CO4 Different methods for Post-processing of 3D Printing parts CO5. Applications of 3D Printing in Automobile, Aerospace, Bio-medical etc.

3 D Printing Process and Application	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
MEDP 421	CO5									1					
	CO1	2	1	2		1	1		1		1	2	1		
	CO2	2	1		1				1		1	2	2		
	CO3	1		2			1	1		1	1	1	1		
	CO4	1						1							

Course Code	Course Title	L	T	P	Credit
MEEV-421	**Smart sensors**	3	0	0	3

Course Objective:

1. To make students familiar with the constructions and working principle of different types of sensors and transducers
2. To make students aware about the measuring instruments and the methods of measurement and the use of different transducers

UNIT – I Mechanical and Electromechanical sensor: Definition, principle of sensing & transduction, classification. Resistive (potentiometric type): Forms, material, resolution, accuracy, sensitivity. Strain gauge: Theory, type, materials, design consideration, sensitivity, gauge factor, variation with temperature, adhesive, rosettes. Inductive sensor: common typesReluctance change type, Mutual inductance change type, transformer action type, Magnetostrictive type, brief discussion with respect to material, construction and input output variable, Ferromagnetic plunger type, short analysis. LVDT: Construction, material, output input relationship, I/O curve, discussion. Proximity sensor

UNIT – II Capacitive sensors: Variable distance-parallel plate type, variable area- parallel plate, serrated plate/teeth type and cylindrical type, variable dielectric constant type, calculation of sensitivity. Stretched diaphragm type: microphone, response characteristics. Piezoelectric element: piezoelectric effect, charge and voltage co-efficient, crystal model, materials, natural & synthetic type, their comparison, force & stress sensing, ultrasonic sensors

UNIT – III Thermal sensors: Material expansion type: solid, liquid, gas & vapor Resistance change type: RTD materials, tip sensitive & stem sensitive type, Thermister material, shape, ranges and accuracy specification. Thermo emf sensor: types, thermoelectric power, general consideration, Junction semiconductor type IC and PTAT type. Radiation sensors: types, characteristics and comparison. Pyroelectric type.

UNIT – IV Magnetic sensors: Sensor based on Villari effect for assessment of force, torque, proximity, Wiedemann effect for yoke coil sensors, Thomson effect, Hall effect, and Hall drive,

UNIT – V Performance characteristics. Radiation sensors: LDR, Photovoltaic cells, photodiodes, photo emissive cell types, materials, construction, response. Geiger counters, Scintillation detectors, Introduction to smart sensors

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TEXT BOOK

1. Sensor & transducers, D. Patranabis, 2nd edition, PHI
2. Instrument transducers, H.K.P. Neubert, Oxford University press.
3. Measurement systems: application & design, E.A.Doebelin, Mc Graw Hill

Course Outcome:

Upon completion of this course, Students should be able to

1. Use concepts in common methods for converting a physical parameter into an electrical quantity

2. 2. Classify and explain with examples of transducers, including those for measurement of temperature, strain, motion, position and light
3. 3. Choose proper sensor comparing different standards and guidelines to make sensitive measurements of physical parameters like pressure, flow, acceleration, etc
4. 4. Predict correctly the expected performance of various sensors
5. 5. Locate different type of sensors used in real life applications and paraphrase their importance

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	P08	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	1	2	1			1	2	2	1	1	1	2	2
CO2	2	3	1	2	1			2	2	2	2	2	2	2	2
CO3	3		2			1	1		1	3	1				
CO4	2	1	3	1		1	1	2	1	1	1	1	1	1	1
CO5	2	1	1	1		2		2	1	2	1	1	1	1	1

ELECTIVE IV

Course code	Course title	L	T	P	Credits
ME-423	Automotive Engineering	3	0	0	3

Course objective:

6. Knowledge about the basic automobile engineering.
7. Understanding of the terminologies of the automobile engines.
8. Analysis of the working of automobile engines.

UNIT 1: **SI ENGINE FUEL SYSTEM**

Requirements; Tanks; filters; fuel lines: metallic and flexible; Fuel pumps: mechanical and electrical; Fuel filters: inline; sediment bowl; Air cleaner: types; functions; thermostatically controlled fuel gauge; Carburation and carburetor; air-fuel ratios: stoichiometric Effect of air-fuel ratio on efficiency and fuel consumption; Factors for fuel carburetion; MPFI: Electronic fuel injection system; Subsystems: air intake system; fuel delivery system; Fuel System Components : Fuel pump; fuel pressure regulator; (Hours-8)

UNIT 2: **CI ENGINE FUEL SYSTEM**

Fuel system layout; Fuel tank; fuel lines; high pressure lines; fuel filters: coarse and fine; Feed pumps : diaphragm type and plunger type; Injection pumps : inline and rotary : description and working; Governors : mechanical; pneumatic and hydraulic; Injectors: types; Supercharger: types; Turbocharger: requirements; design; (Hours-8)

UNIT 3: **COMBUSTION – SI ENGINES**

Theory of combustion; Combustion reaction requirements; Types of CC; Advantages and disadvantages; Supercharging SI engines: Advantages; Detonation; pre-ignition: Differences and Prevention; Effect of compression ratio on knock; Stages of combustion;

flame propagation; rate of pressure rise; Required characteristic of gasoline rating: HUCR; octane number; performance number; Dieseling; Causes of abnormal Combustion. (Hours-8)

UNIT 4: **COMBUSTION – CI ENGINES**

Chemistry of Diesel combustion; Requirements of diesel fuel combustion; Ignition Delay: pressure: time diagram: factors causing ignition delay; Phases of normal Combustion; Properties of diesel fuel; Effects of high or low Centane number; Diesel knock and Cetane Number; Diesel engine combustion chambers: direct and indirect injection; comparison (Hours-8)

UNIT 5: **NON-CONVENTIONAL ENGINES**

Wankel Rotary CI engine: Principle; geometry; swept volume; C; advantages and disadvantages; Applications; Gas turbine engines: classification, major components: compressor, turbine, regenerator, combustor, transmission, Fuel requirements; performance; Advantages; Stratified charge engine: methods of charge stratification : Fuel injection and positive ignition; characteristics of stratified charge engines; Applications; Advantages and; disadvantages. (Hours-8)

TEXT BOOK

1. Internal Combustion Engines, Er R K Rajput, Third Edition, LP

REFERENCE BOOK

1.

Course outcomes:
CO1: Knowledge about the fuel system in SI engine. CO2: Knowledge about the fuel system in CI engine. CO3: Apply combustion process in SI engine. CO4: Apply combustion process in CI engine. CO5: Understanding of unconventional engines.

Subject name Automotive Engineering ME-423	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	3								1				2	
	CO2			2										2	

	CO3	2				2							1	
	CO4	1		2								2	2	
	CO5				3								1	

Course code	Course title	L	T	P	Credits
MEDP-423	Product design and development	3	0	0	3

Course objective:
This course aims at introducing the students to the basic concepts of engineering design and product development with focus on the front end processes. At the end of this course the student is expected to demonstrate an understanding of the overview of all the product development processes and knowledge of concept generation and selection tools.

UNIT-1: Need for developing products – the importance of engineering design – types of design –the design process – relevance of product lifecycle issues in design –designing to codes and standards- societal considerations in engineering design –generic product development process – various phases of product development-planning for products – establishing markets- market segments- relevance of market research

UNIT-2: Identifying customer needs –voice of customer –customer populations- hierarchy of human needs-need gathering methods – affinity diagrams – needs importance- establishing engineering characteristics-competitive benchmarking- quality function deployment- house of quality- product design specification-case studies

UNIT-3: Creative thinking –creativity and problem solving- creative thinking methods-generating design concepts-systematic methods for designing –functional decomposition – physical decomposition –functional representation –morphological methods-TRIZ- axiomatic design

UNIT-4: Decision making –decision theory –utility theory –decision trees –concept evaluation methods –Pugh concept selection method- weighted decision matrix –analytic hierarchy process – introduction to embodiment design –product architecture – types of modular architecture –steps in developing product architecture

UNIT-5: Industrial design – human factors design –user friendly design – design for serviceability – design for environment – prototyping and testing – cost evaluation – categories of cost – overhead costs – activity based costing –methods of developing cost estimates – manufacturing cost –value analysis in costing

TEXT BOOKS

.**1.** Anita Goyal, Karl T Ulrich, Steven D Eppinger, "Product Design and Development ", 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9

2. Clive L.Dym, Patrick Little, "Engineering Design: A Project-based Introduction", 3rd

Edition, John Wiley & Sons, 2009, ISBN 978-0-470-22596-7
3. George E.Dieter, Linda C.Schmidt, "Engineering Design", McGraw-Hill International Edition, 4th Edition, 2009, ISBN 978-007-127189-9

REFERENCE BOOKS:

1. Kevin Otto, Kristin Wood, "Product Design", Indian Reprint 2004, Pearson Education,ISBN 9788177588217
2. Yousef Haik, T. M. M. Shahin, "Engineering Design Process", 2nd Edition Reprint, Cengage Learning, 2010, ISBN 0495668141

Course outcomes:
CO1. Understand advance Computer aided design software (UG & Catia) as compare to other CAD software.
CO2. Create 2D geometric sketches by using UG & Catia software.
CO3. Develop 3D solid & surface modeling by using advanced command.
CO4. Understand modern product development processes. ·
CO5. Understand and explain the concept of Industrial design and robust design concepts

Product design and development MEDP-4223	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	3				2					1		1		
	CO2	3			1					1			1		
	CO3	3		1	2				1		1		1		
	CO4	3					2				1				
	CO5	2			2					1		1	1		

Course code	Course title	L	T	P	Credits
MEEV-423	EV battery and charging system	3	0	0	3

Course Objective:
1. To understand the different types of energy storage system. 2. To study about the battery characteristic & parameters. 3. To model the types of batteries 4. To know the concepts of battery management system and design the battery pack. 5. To study about the battery testing, disposal and recycling.

UNIT – I ENERGY STORAGE SYSTEM

Batteries: Lead Acid Battery, Nickel based batteries, Sodium based batteries, Lithium based batteries – Li-ion & Li-poly, Metal Air Battery, Zine Chloride battery; Ultra capacitors; Flywheel Energy Storage System; Hydraulic Energy Storage System; Comparison of different Energy Storage System.

UNIT – II BATTERY CHARACTERISTICS & PARAMETERS

Cells and Batteries- conversion of chemical energy to electrical energy- Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parameters- Heat generation- Battery design- Performance criteria for Electric vehicles batteries- Vehicle propulsion factors- Power and energy requirements of batteries- Meeting battery performance criteria- setting new targets for battery performance.

UNIT – III BATTERY MODELLING

General approach to modelling batteries, simulation model of a rechargeable Li-ion battery, simulation model of a rechargeable Ni-Cd battery, Parameterization of the Ni-Cd battery model, Simulation examples.

UNIT – IV BATTERY PACK AND BATTERY MANAGEMENT SYSTEM

Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, protection interface, SOC Estimation, Energy & Power estimation, Battery thermal management system, Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, load, communication channel, Battery Pack Safety, Battery Standards & Tests.

UNIT – V BATTERY TESTING, DISPOSAL & RECYCLING

Chemical & structure material properties for cell safety and battery design, battery testing, limitations for transport and storage of cells and batteries, Recycling, disposal and second use of batteries. Battery Leakage: gas generation in batteries, leakage path, leakage rates. Ruptures: Mechanical stress and pressure tolerance of cells, safety vents, Explosions: Causes of battery explosions, explosive process, Thermal Runway: High discharge rates, Short circuits, charging and discharging. Environment and Human Health impact assessments of batteries, General recycling issues and drivers, methods of recycling of EV batteries.

TEXT BOOK

1. Ibrahim Dinçer, Halil S. Hamut and Nader Javani, “Thermal Management of Electric Vehicle Battery Systems”, John Wiley& Sons Ltd., 2016.
2. Chris Mi, Abul Masrur& David Wenzhong Gao, “Hybrid electric Vehicle- Principles & Applications with Practical Properties”, Wiley, 2011.
3. Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric Hybrid Electric and Fuel Cell Vehicles”, Taylor& Francis Group, 2010.
4. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, John Wiley & Sons Ltd, 2003.

REFERENCES

1. G. Pistoia, J.P. Wiaux, S.P. Wolsky, “Used Battery Collection and Recycling”, Elsevier, 2001. (ISBN: 0-444-50562-8)
2. Guangjin Zhao, “Reuse and Recycling of Lithium-Ion Power Batteries”, John Wiley & Sons. 2017. (ISBN: 978-1-1193-2185-9)
3. T R Crompton, “Battery Reference Book-3rd Edition”, Newnes- Reed Educational and Professional Publishing Ltd., 2000.

4. Arno Kwade, Jan Diekmann, "Recycling of Lithium-Ion Batteries: The LithoRec Way", Springer, 2018. (ISBN: 978-3-319-70571-2).

Course Outcome:
Upon completion of this course, Students should be able to 1. Discuss about the different types of energy storage system. 2. Describe about the battery characteristic & parameters. 3. Model different types of batteries 4. Apply the concepts of battery management system and design the battery pack. 5. Explain about the battery testing, disposal and recycling.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	P08	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	1	2	1			1	2	2	1	1	1	2	2
CO2	2	3	1	2	1			2	2	2	2	2	2	2	2
CO3	3		2			1	1		1	3	1				
CO4	2	1	3	1		1	1	2	1	1	1	1	1	1	1
CO5	2	1	1	1		2		2	1	2	1	1	1	1	1

ELECTIVE V

Course code	Course title	L	T	P	Credits
ME-422	Industrial Automation	3	0	0	3

Course objective:
1. Knowledge about the basics of industrial automation. 2. Applying PLC fundamentals 3. Understanding electric drives and its applications

UNIT 1: **Introduction to industrial Automation**

Need and benefits of industrial automation, Automation Hierarchy, Basic components of automation system, types of automation system; fixed, programmable, flexible, different systems for industrial automation: PLC, HMI, SCADA, DCS, Drives (Hours-8)

UNIT 2: **PLC fundamentals**

Building blocks of PLC: CPU, Memory organization, Input-output modules (discrete and analog), special I/O Modules, power supply, fixed and modular PLC and their types, redundancy in PLC module, I/O module selection criteria (Hours-8)

UNIT 3: **PLC Programming and Application**

PLC I/O addressing, PLC programming instructions: Relay type instructions, timer instructions: On delay, off delay, retentive, counter instructions, logical instructions, comparison instructions, PLC programming language- Functional block diagram, Sequential Function Chart. (Hours-8)

UNIT 4: **Electric drives and special machines**
Electric drives: types, functions, characteristics, DC and AC drives, Parameters, direct torque control, Drives: working principle, specification, parameters, types and applications, Applications: Speed control of AC/DC motor. (Hours-8)

UNIT 5: **Supervisory control and data acquisition system**
Introduction to SCADA, typical SCADA architecture/block diagram, benefits of SCADA, Interfacing of SCADA system with PLC, Application of SCADA: Traffic light control, water distribution, pipeline control (Hours-8)

TEXT BOOK

1. Programmable Logic controller, Jadhav V R, Khanna Publishers,2017
2. Programmable logic controllers, Petruzella F D, Tata McGraw Hill India, 2010.

REFERENCE BOOK

1. Industrial automation and process control, Stenerson Jon, PHI Learning.
2. Programmable logic controllers, Hackworth John, PHI Learning.

Course outcomes:
CO1: Identify different components of an automation system. CO2: Interface the given I/O device with appropriate PLC module. CO3: Prepare a PLC program for the given application. CO4: Select the suitable motor drives for the specified application. CO5: Prepare a simple SCADA application

Industrial Automation ME 422	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	3								1				2	
	CO2			2										2	
	CO3	2				2								1	
	CO4	1		2									2	2	
	CO5				3									1	

Course code	Course title	L	T	P	Credits
MEDP-422	Metal additive manufacturing	3	0	0	3

Course objective:
The course should enable the students to: 1. To introduce students the basics of additive manufacturing/rapid prototyping and its applications in various fields, reverse engineering techniques. 2.To familiarize students with different processes in rapid prototyping systems.

UNIT-I : Introduction to Additive Manufacturing (AM)

Manufacturing Systems, Subtractive Manufacturing , Need for additive manufacturing (AM), Classification of additive manufacturing ,application challenges and opportunities of metal additive manufacturing. System setup of AM machines, laser theory, laser components, continuous vs pulsed laser, laser types, laser beam properties
Equilibrium and non equilibrium phases for solidification, theory and mechanism for solidification- in equilibrium phase for AM, in non-equilibrium phase for AM, Raw MAM printed parts, Phase diagrams for Iron-Carbon, aluminum alloy, titanium alloy, nickel alloy, Printing processes, Modelling and data processing, design consideration, machine set up, powder bed fusion (PBF), directed energy deposition (DED), binder jetting (BJ), emerging metal AM processes- material extrusion, material jetting, sheet lamination

Unit 2 Metal AM physics and processes, Directed Energy, Binder and Material Jetting

AM process parameters, beam scanning strategies and parameters for PBF and DED, powder properties for PBF, DED and BJ, methods of powder particles production, wire properties for DED, ambient parameters for EBF and DED, geometry- specific parameters (PBF), support structures for PBF, Mechanical properties of AM printed parts, hardness of AM printed alloys, tensile and static strength of AM printed alloys, fatique behavior of AM manufactured alloys, common defects in AM printed alloys, need of post processing, need for surface finishing, common post processing for MAM

Unit 3 Feedstocks, metallurgy and properties of materials

Conventional manufacturing techniques for metal matrix composites, additive manufacturing techniques of metal matrix composites, AM challenges and opportunities, preparation of composite materials- mechanical mixing, AM of ferrous matrix composites, titanium matrix composites (TMCs), aluminium matrix composites, nickel matrix composites, factors affecting composite properties.

Unit 4 Reverse Engineering for metal AM

Reverse engineering, reverse engineering process, industries, purposes, methodology and stages in reverse engineering, reverse engineering in AM, different scanners

Unit 5 Non destructive testing

Non destructive testing, contact methods- ultrasonic testing, eddy current testing, magnetic testing, penetrant testing, acoustic testing, non contact methods- radiography testing, thermo graphic testing, visual inspection, x-ray computed tomography

Text Books

1. Additive Manufacturing of Metals: From Fundamental Technology to Rocket Nozzles, Medical Implants, and Custom Jewelry (Springer Series in Materials Science, 258) by John O. Milewski
2. Metal Additive Manufacturing by by Dyuti Sarker , Ehsan Toyserkani , Wiley.

Reference Books

1. Leila Ladani's book on the 'Additive Manufacturing of Metals: Materials, Processes, Tests, and Standards' (DEStech Publications, Inc.)
2. Precision Metal Additive Manufacturing By Richard Leach, Simone Carmignato ,Taylor & Francis eBooks.
3. Metal Additive Manufacturing , Ehsan Toyserkani, Dyuti Sarker, Osezua Obehi Ibhadode, Farzad Liravi, Paola Russo, Katayoon Taherkhani , Wiley

Course outcomes:
CO1. Develop a comprehensive understanding of fundamental additive manufacturing – alternatively, "three-dimensional (3D) printing" – approaches, including extrusion-based deposition, stereolithography, powder bed-based melting, and inkjet-based deposition.
CO2. Cultivate a "design-for-additive manufacturing" skillset for combining computer-aided design (CAD) and computer-aided manufacturing (CAM) methodologies to produce successful 3D prints.
CO3. Fabricate 3D mechanical objects using a variety of 3D printing technologies on campus.
CO4. Execute a design project that demonstrates how additive manufacturing technologies can overcome critical limitations of traditional manufacturing processes.

Metal additive manufacturing MEDP-422	**Course outcomes**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	2		2		1		2	2		1		1		
	CO2	3			2			1		1			1	2	
	CO3	3		2	1				2		1		1	1	
	CO4	2					1	1			1			1	

Course Code	Course Title	L	T	P	Credit
MEEV-422	**Hybrid electric vehicle technology**	3	0	0	3

Course Objective:
1. Understand the architecture and vehicle dynamics of electric and hybrid vehicles 2. Analyze and model the power management systems for electric and hybrid vehicles 3. Devise power electronics based control strategies for electric and hybrid vehicles

UNIT – I Hybrid and Electric Vehicles (HEV): History Overview and Modern Applications Ground vehicles with mechanical powertrain and reasons for HEV development . HEV configurations and ground vehicle applications. Advantages and challenges in HEV design. Mechanical power: generation, storage and transmission to the wheels Electric power: generation, storage and conversion to mechanical power Hydraulic power: generation, storage and conversion to mechanical power

UNIT – II Energy storage/conversion and thermodynamic relations. Vehicle chassis mathematical model in various operation conditions (steady motion, acceleration, regenerating braking, coasting, moving up and down a hill). Series HE powertrain mathematical model. Computer model of the HEV.

UNIT – III Vehicle Testing Laboratory Works – continuation. 4x4 Vehicle Chassis Dynamometer: Programmed Force Test. Mechanical Drivetrain Engineering. Driving axle designs and characteristics. Automatic transmission designs and characteristics

UNIT – IV Mechanical Drivetrain Engineering – continuation. Planetary gear sets in transmission design. Vehicle applications at different modes of operation. Electric Drives. DC-Brushed and brushless drives: principles of design, operation, math modeling and control Ø Shunt Drives Ø Series Drives Ø Compound Drive

UNIT – V Wheel-Electric Drive, Suspension System Design. Gear trains in wheel-electric drives. Mechatronic design of wheel-electric drives. Suspension design for wheel-electric drives. Wheel-Electric Drive, Suspension System Design - continuation . Wheel/Tire-terrain interactive dynamics . Inverse dynamics-based control.

TEXT BOOK

1. Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure and the Market by Gianfranco Pistoia

2. Energy Systems for Electric and Hybrid Vehicles by K.T. Chau

Course Outcome:

Upon completion of this course, Students should be able to

1. Understand the architecture and vehicle dynamics of electric and hybrid vehicles
2. Analyze and model the power management systems for electric and hybrid vehicles
3. Devise power electronics based control strategies for electric and hybrid vehicles
4. Analyze and design various components of electric and hybrid vehicles with environment concern.
5. Investigate and model the issues in mathematical domain related to grid interconnections of electric and hybrid vehicle.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	P08	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	1	2	1			1	2	2	1	1	1	2	2
CO2	2	3	1	2	1			2	2	2	2	2	2	2	2
CO3	3		2			1	1		1	3	1				
CO4	2	1	3	1		1	1	2	1	1	1	1	1	1	1
CO5	2	1	1	1		2		2	1	2	1	1	1	1	1

ELECTIVE VI

Course code	Course title	L	T	P	Credits
ME-424	Unconventional machining process	3	0	0	3

Course objective:

1.It provides an insight of machines associated with specialized production. The purpose of this course is also to learn the need for various non– traditional machining methods

UNIT I INTRODUCTION AND MECHANICAL ENERGY BASED PROCESSES

Unconventional machining Process – Need – classification – merits, demerits and applications. Abrasive Jet Machining – Water Jet Machining – Abrasive Water Jet Machining - Ultrasonic Machining. (AJM, WJM, AWJM and USM). Working Principles – equipment used – Process parameters – MRR- Applications.

UNIT II THERMAL AND ELECTRICAL ENERGY BASED PROCESSES

Electric Discharge Machining (EDM) – Wire cut EDM – Working Principle-equipments-Process Parameters-Surface Finish and MRR- electrode / Tool – Power and control Circuits-Tool Wear – Dielectric – Flushing — Applications. Laser Beam machining and drilling, (LBM), plasma, Arc machining (PAM) and Electron Beam Machining (EBM). Principles – Equipment –Types - Beam control techniques – Applications.

UNIT III CHEMICAL AND ELECTRO-CHEMICAL ENERGY BASED PROCESSES

Chemical machining and Electro-Chemical machining (CHM and ECM)- Etchants – Maskant - techniques of applying maskants - Process Parameters – Surface finish and MRR-

Applications. Principles of ECM- equipments-Surface Roughness and MRR Electrical circuit-Process Parameters- ECG and ECH - Applications.

UNIT IV ADVANCED NANO FINISHING PROCESSES

Abrasive flow machining, chemo-mechanical polishing, magnetic abrasive finishing, magneto rheological finishing, magneto rheological abrasive flow finishing their working principles, equipments, effect of process parameters, applications, advantages and limitations.

UNIT V RECENT TRENDS IN NON-TRADITIONAL MACHINING PROCESSES

Recent developments in non-traditional machining processes, their working principles, equipments, effect of process parameters, applications, advantages and limitations. Comparison of non-traditional machining processes.

Text book:

1. K. Jain, "Advanced Machining Processes", Allied Publishers, 1st Edition, 2013.
2. 2. Pandey P. C., Shah H.S., "Modern Machining Processes", Tata McGraw-Hill, 1st Edition, 2013.

References:

1. Bhattacherya A, "New Technology", The Institute for Engineers, 1st Edition, 1973.
2. C. Elanchezhian, B. Vijaya Ramnath, M. Vijayan, "Unconventional Machining processes", Anuradha Publication, 1st Edition, 2005.
3. M. K. Singh, "Unconventional Machining processes", New Age International Publishers, 1st Edition, 2010

Course outcomes:
CO 1. Compare non-traditional machining, classification, material applications in material removal process
CO 2. Summarize the principle and processes of abrasive jet machining.
CO 3. Understand the principles, processes and applications of thermal metal removal processes.
CO 4. Identify the principles, processes and applications of EBM.
CO 5. Understand the principles, processes and applications of Plasma Machining.

Unconventional machining process ME 424	**Course outcomes**	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
	CO1	2		2		1		2	2		1		1		
	CO2	3			2			1		1			1	2	
	CO3	3		2	1				2		1		1	1	

CO4	2					1	1			1			1	
CO5	1			2					2		1	1		

Course Code	Course Title	L	T	P	Credit
MEEV-424	**Electrical and autonomous road vehicle**	3	0	0	3

Course Objective:

1. To gain knowledge in the field of E-vehicle certification.
2. To understand the concept of static testing of E-vehicle.
3. To understand the concept of dynamic testing of E-vehicle.
4. To study about various E-vehicle component testing.
5. To understand the fundamentals of charging station & hybrid electric vehicle testing.

UNIT – I INTRODUCTION

Specification & Classification of Vehicles (including M, N and O layout), Homologation & its types, Regulations overview (EEC, ECE, FMVSS, AIS, CMVR), Type approval Scheme, Homologation for export, Conformity of Production, various Parameters, Instruments and Types of test tracks, Hardware in The Loop (HIL) concepts for EV/HEVs.

UNIT – II STATIC TESTING OF VEHICLE

Photographs, CMVR physical verification, Tyre Tread Depth Test, Vehicle Weightment, Horn installation, Rear view mirror installation, Tell Tales, External Projection, Wheel Guard, Arrangement of Foot Controls for M1 Vehicle, Angle & Dimensions Measurement of Vehicle, The requirement of temporary cabin for drive– away – Chassis, electric vehicle – Safety norms, Energy consumption and power test.

UNIT – III DYNAMICS TESTING OF VEHICLE

Hood Latch, Grade ability, Pass-by Noise, Interior Noise, Turning Circle Diameter & Turning Clearance Circle Diameter, Steering Effort, Constant Speed Fuel Consumption, Cooling Performance, Speedo-meter Calibration, Range Test, Maximum Speed, Acceleration Test, Coast-down test, Brakes Performance ABS Test, Broad band / Narrow band EMI Test, Electric vehicle – Range Test.

UNIT – IV VEHICLE COMPONENT TESTING

Horn Testing, Safety Glasses Test: Windscreen laminated and toughened safety glass, Rear View Mirror Test, Hydraulic Brakes Hoses Fuel Tank Test: Metallic & Plastic, Hinges and Latches Test, Tyre & Wheel Rim Test, Bumper Impact Test, Side Door Intrusion, Crash test with dummies, Demist test, Defrost Test, Interior Fittings, Steering Impact test (GVW<1500 kg), Body block test, Head form test, Driver Field of vision, Safety belt assemblies, Safety belt anchorages, Seat anchorages & head restraints test, Airbag Test, Accelerator Control System, Motor power, Safety Requirements of Traction Batteries, EMI-EMC (CI, BCI, RE,RI and CTE).

UNIT – V TESTS FOR HYBRID ELECTRIC VEHICLES, RETRO-FITMENT AND CHARGING STATION

Hybrid Electric Vehicles Tests (M and N category), Tests for Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category (GVW < 3500 kg), Test for Electric Propulsion kit intended for Conversion, Test for Electric Vehicle Conductive AC Charging System, and Test for Electric vehicle conductive DC charging system.

TEXT BOOK

1. "Vehicle Inspection Handbook", American Association of Motor Vehicle Administrators
2. Michael Plint & Anthony Martyr, "Engine Testing & Practice", Butterworth Heinmenn, 3rd ed, 2007

REFERENCES

1. Proceedings- Automotive Testing & Certification held on 20th to 24th July 2010 at ARAI, PUNE
2. Bosch Automotive Handbook, Robert Bosch, 7th Edition, 2007.

Course Outcome:
Upon completion of this course, Students should be able to 1. Gain knowledge in the field of E-vehicle certification. 2. Explain the concept of static testing of E-vehicle. 3. Explain the concept of dynamic testing of E-vehicle. 4. Know about various E-vehicle component testing. 5. Gain the insight of charging station & hybrid electric vehicle testing.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	P08	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	1	2	1			1	2	2	1	1	1	2	2
CO2	2	3	1	2	1			2	2	2	2	2	2	2	2
CO3	3		2			1	1		1	3	1				
CO4	2	1	3	1		1	1	2	1	1	1	1	1	1	1
CO5	2	1	1	1		2		2	1	2	1	1	1	1	1