BVVS

BASAVESHWAR BVVS

BASAVESHWAR ENGINEERING COLLEGE, BAGALKOT - 587102

BE. in Mechanical Engineering

Scheme of Teaching and Examinations (2022-23 admitted 1st year students and 2023-24admitted Lateral Entry Students)

(Academic Year 2024-25)

III SEMESTER

Sl. No.	Course	Course Code	Course Title	Teaching Department (TD) and Question Paper Setting Board (PSB)	Teaching Hours /Week				Examination				
					Theory/ Lecturer	Tutorials	Practical / Drawing	Self - Study	Duration in Hours	CIE Marks	SEE Marks	Total Marks	Credits
					L	T	P	S					
1	PCC	22UME311C	Mechanics of Materials	ME	3	0	0	0	03	50	50	100	3
2	IPCC	22UME312C	Manufacturing Process	ME	3	0	2	0	03	50	50	100	4
3	IPCC	22UME313C	Material Science and Engineering	ME	3	0	2	0	03	50	50	100	4
4	PCC	22UME314C	Basic Thermodynamics	ME	3	0	0	0	03	50	50	100	3
5	PCCL	22UME315L	Introduction to Modelling and Design for Manufacturing	ME	0	0	2	0	03	50	50	100	1
6	ESC	22UME32XX	ESC/ETC/PLC	ME	3	0	0	0	01	50	50	100	3
7	UHV	22UHS317L	**Social Connect and Responsibility**	Any Dept	0	0	0	1	01	100	---	100	1
8	AEC/SEC	22UME33XX	Ability Enhancement Course/Skill Enhancement Course - III	ME	If the course is a theory 1	0	0	0	01	50	50	100	1
					If the course is a laboratory 0	0	2	0	02				
9	MC	22UHS001M	Yoga	Yoga Teacher	0	0	2	0	02	100	---	100	0
		22UHS002M	National Service Scheme (NSS)	NSS Coordinator									
		22UHS003M	Physical Education (PE) (Sports and Athletics)	PE Director									
		22UHS004M	Music	Music Teacher									
TOTAL									**18**	**550**	**350**	**900**	**20**

PCC: Professional Core Course, **PCCL**: Professional Core Course laboratory, **UHV**: Universal Human Value Course, **MC**: Mandatory Course (Non-credit), **AEC**: Ability Enhancement Course, **SEC**: Skill Enhancement Course, **L:** Lecture, **T**: Tutorial, **P**: Practical **S=** Self -Study, **CIE**: Continuous Internal Evaluation, **SEE**: Semester End Evaluation:. ESC: Engineering Science Course, ETC: Emerging Technology Course.

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Engineering Science Course (ESC/ETC/PLC)[L-T-P::3- 0-0]			
22UME321C	Electric and Hybrid Vehicle Technology	22UME322C	Internet of Things (IoT)
22UME3213C	Smart Materials & Systems	22UME324C	Waste handling and Management
Ability Enhancement Course – III			
22UME331C	Advanced Python Programming [0-0-2]	22UME332C	Spreadsheet for Engineers [0-0-2]
22UME333C	Introduction to Virtual Reality [0-2-0]	22UME334C	Tools in Scientific Computing [0-0-2]

Professional Core Course (IPCC): Refers to Professional Core Course Theory Integrated with practical's of the same course. Credit for IPCC can be 04 and its Teaching– Learning hours (L : T : P) can be considered as (3 : 0 : 2) or (2 : 2 : 2). The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE). However, questions from the practical part of IPCC shall be included in the SEE question paper. For more details, the regulation governing the Degree of Bachelor of Engineering /Technology (B.E./B.Tech.) 2022-23 may please be referred.

National Service Scheme /Physical Education/Yoga: All students have to register for any one of the courses namely National Service Scheme (NSS), Physical Education (PE)(Sports and Athletics), Yoga(YOGA) and Music with the concerned coordinator of the course during the first week of III semesters. Activities shall be carried out between III semesters to the VI semester (for 4 semesters). Successful completion of the registered course and requisite CIE score is mandatory for the award of the degree. The events shall be appropriately scheduled by the colleges and the same shall be reflected in the calendar prepared for the NSS, PE, and Yoga activities. These courses shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the course is mandatory for the award of degree.

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IV SEMESTER

Sl. No.	Course	Course Code	Course Title	Teaching Department (TD) and Question Paper Setting Board (PSB)	Teaching Hours /Week				Examination				
					Theory/ Lecturer	Tutorials	Practical / Drawing	Self - Study	Duration in Hours	CIE Marks	SEE Marks	Total Marks	Credits
					L	T	P	S					
1	PCC	22UME411C	Applied Thermodynamics	ME	3	0	0	0	03	50	50	100	3
2	IPCC	22UME412C	Machining Science & Metrology	ME	3	0	2	0	03	50	50	100	4
3	IPCC	22UME413C	Fluid Mechanics	ME	3	0	2	0	03	50	50	100	4
4	PCCL	22UME414L	Mechanical Measurements and Metrology lab	ME	0	0	2	0	03	50	50	100	1
5	ESC	22UME42XC	ESC/ETC/PLC -IV	ME	3	0	0	0	03	50	50	100	3
6	AEC	22UMEXXX	AEC-IV	ME	1	0	0	0	01	50	50	100	1
7	BSC	22XXXXXX	Biology For Engineers	BT	3	0	0	1	01	50	50	100	3
8	UHV	22XXXXXX	Universal Human Values	HSS	1	0	0	0	01	50	50	100	1
9	MC	22UHS001M	Yoga	Yoga Teacher	0	0	2	0	02	100	---	100	0
		22UHS002M	National Service Scheme (NSS)	NSS Coordinator									
		22UHS003M	Physical Education (PE) (Sports and Athletics)	PE Director									
		22UHS004M	Music	Music Teacher									
TOTAL									**20**	**500**	**400**	**900**	**20**

PCC: Professional Core Course, **PCCL**: Professional Core Course laboratory, **UHV**: Universal Human Value Course, **MC**: Mandatory Course (Non-credit), **AEC**: Ability Enhancement Course, **SEC**: Skill Enhancement Course, **L:** Lecture, **T**: Tutorial, **P**: Practical **S=** Self study: Skill Development Activity, **CIE**: Continuous Internal Evaluation, **SEE**:Semester End Evaluation. K :This letter in the course code indicates common to all the stream of engineering.

Engineering Science Course (ESC/ETC/PLC) [L-T-P::3-0-0]			
22UME421C	Non Traditional Machining	22UME422C	Micro Electro Mechanical Systems
22UME423C	Environmental Studies	22UME424C	Robotics and Automation
Ability Enhancement Course / Skill Enhancement Course - IV			
22UME431C	Introduction to AI & ML [0-0-2]	22UME434C	Introduction to Data Analytics [0-0-2]
22UME433C	Digital Marketing [0-2-0]	22UME432C	Introduction to Programming in C++ [0-0-2]

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V SEMESTER

Sl. No.	Course	Course Code	Course Title	Teaching Department (TD) and Question Paper Setting Board (PSB)	Teaching Hours /Week				Examination				Credits
					Theory/ Lecturer	Tutorials	Practical / Drawing	SDA	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
1	PCC	22UME511C	Design of Machine Element	ME	3	0	0		03	50	50	100	03
2	PCC	22UME512C	Composite Materials and Processing	ME	3	0	0		03	50	50	100	03
3	PCC	22UME513C	Energy Conversion Technology	ME	3	0	0		03	50	50	100	03
4	PEC	22UME5XXE	Professional Elective - I	ME	3	0	0		03	50	50	100	03
5	OEC	22UME5XXN	Open Elective - I	Other Dept.	3	0	0		03	50	50	100	03
6	PROJ	22UME541P	Mini Project	ME	0	0	4		02	50	50	100	02
7	HSS	22UBT523C	Environmental Studies	BT	1	0	0		01	50	50	100	01
8	HSS	22UHS521C	Quantitative Aptitude and Professional Skills	HSS	2	0	0		02	50	50	100	02
9	MC	22UHS001M	Yoga	Yoga Teacher	0	0	2	0	02	100	---	100	0
		22UHS002M	National Service Scheme (NSS)	NSS Coordinator									
		22UHS003M	Physical Education (PE) (Sports and Athletics)	PE Director									
								TOTAL	**22**	**500**	**400**	**900**	**20**

Professional Elective Course - I [L-T-P::3-0-0]			
22UME521E	Quality and Reliability Engineering	22UME522E	Robotics and Automation
22UME523E	Supply chain Management and Introduction to SAP	22UME524E	Introduction to Artificial Intelligence
Open Elective – I [L-T-P::3-0-0]			
22UME533N	Power Plant Engineering	22UME535N	Fluid Power Automation

MC: Mandatory Course (Non Credit)

Mini-project work: Mini Project is a laboratory-oriented/hand on course that will provide a platform to students to enhance their practical knowledge and skills by the development of small systems/applications etc. Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary Mini- project can be assigned to an individual student or to a group having not more than 4 students.

Professional Elective Courses (PEC): A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum. Multidisciplinary courses that are added supplement the latest trend and advanced technology in the selected stream of engineering. Each group will provide an option to select one course. The minimum number of students' strengths for offering professional electives is 12. However, this conditional shall not be applicable to cases where the admission to the program is less than 20.

Open Elective Courses (OEC): Students belonging to Mechanical Engineering are not entitled to the open electives offered by their parent Department. However, they can opt for an elective offered by other Departments, provided they satisfy the prerequisite condition if any. Registration to open electives shall be documented as per the regulations of College. The minimum numbers of students' strength for offering Open Elective Course is 20.

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Scheme of Teaching and Examinations AY: 2024-25

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VI SEMESTER

Sl. No.	Course	Course Code	Course Title	Teaching Department (TD) and Question Paper Setting Board (PSB)	Teaching Hours /Week				Examination				Credits
					Theory/ Lecturer	Tutorials	Practical / Drawing	SDA	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
1	PCC	22UME611C	Finite Element Methods	ME	3	0	0		03	50	50	100	3
2	IPCC	22UME612C	Heat Transfer	ME	3	0	2		03	50	50	100	4
3	IPCC	22UME613C	Mechanical Vibrations	ME	3	0	2		03	50	50	100	4
4	PCC	22UME614C	Operations Research	ME	3	0	0		03	50	50	100	3
5	PEC	22UME6XXE	Professional Elective Course– II	ME	2	0	0		03	50	50	100	2
6	OEC	22UME6XXN	Open Elective Course- II	Other Dept.	3	0	0		03	50	50	100	3
7	HSS	22UHS 600C	Indian Knowledge System	ME	1	0	0		01	50	50	100	1
8	MC (Non Credit)	22UHS001M	Yoga	Yoga Teacher	**0**	**0**	**2**	**0**	**02**	**100**	**---**	**100**	**0**
		22UHS002M	National Service Scheme (NSS)	NSS Coordinator									
		22UHS003M	Physical Education (PE) (Sports and Athletics)	PE Director									
								TOTAL	**25**	**450**	**350**	**800**	**20**

Professional Elective Course - II [L-T-P::2-0-0]			
22UME621E	Quality Control Engineering	22UME622E	Engineering Economics
22UME623E	Project Management	22UME624E	Reverse Engineering

Open Elective – II [L-T-P::3-0-0]			
22UME631N	Operations Research	22UME632N	Product Design and Rapid Protyping
22UME633N	Turbomachines		

Professional Elective Courses (PEC): A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum. Multidisciplinary courses that are added supplement the latest trend and advanced technology in the selected stream of engineering. Each group will provide an option to select one course. The minimum number of students' strengths for offering professional electives is 12. However, this conditional shall not be applicable to cases where the admission to the program is less than 20.

Open Elective Courses (OEC): Students belonging to Mechanical Engineering are not entitled to the open electives offered by their parent Department. However, they can opt for an elective offered by other Departments, provided they satisfy the prerequisite condition if any. Registration to open electives shall be documented as per the regulations of College.

The preparatory work for the major project shall be initiated during 6th semester for which CIE should be conducted and the marks of the same will be reflected during 7th semester.

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(2022-23 admitted 1st year students and 2023-24 Lateral Entry Students)

VII SEMESTER

Sl. No.	Course	Course Code	Course Title	Teaching Department (TD) and Question Paper Setting Board (PSB)	Teaching Hours /Week				Examination				Credits
					Theory/ Lecturer	Tutorials	Practical / Drawing	SDA	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
1	PCC	22UME711C	Control Engineering	ME	3	0	0		03	50	50	100	3
2	PEC	22UME7XXE	Professional Elective – III	ME	3	0	0		03	50	50	100	3
3	PEC	22UME7XXE	Professional Elective – IV	ME	3	0	0		03	50	50	100	3
4	PROJ	22UME741E	Major Project	ME	0	0	12		03	50	50	100	12
5	HSS	22UHS753C	Intellectual Property Rights	HSS	3	0	0		03	50	50	100	3
								TOTAL	**15**	**250**	**250**	**500**	**24**

Professional Elective Course - III [L-T-P::3-0-0]			
UME721E	Operation Management	UME722E	Non Destructive Testing
UME723E	Product Design and Rapid Prototyping	UME724E	Advanced Manufacturing Technology

Professional Elective Course - IV [L-T-P::3-0-0]			
UME731E	Project Management	UME732E	Fluid Power Automation
UME733E	Lean Manufacturing	UME734E	Product Life Cycle Management

Major Project : The objective of the Project work is

- ✓ To encourage independent learning and the innovative attitude of the students.
- ✓ To develop interactive attitude, communication skills, organization, time management, and presentation skills.
- ✓ To inspire team working.
- ✓ To expand intellectual capacity, credibility, judgment and intuition.
- ✓ To adhere to punctuality, setting and meeting deadlines.
- ✓ To install responsibilities to oneself and others.
- ✓ To train students to present the topic of project work in a seminar without any fear, enhance communication skills and group discussions.

CIE procedure for Project Work:

The CIE marks shall be awarded by a committee consisting of the Head of the Department and two senior faculty members of the department, one of whom shall be the Guide. The CIE marks awarded for the project work, shall be based on the evaluation of the project work; CIE-1 (initiated during 6th semester) and CIE-2 (During 7th semester), project presentation skill, and question and answer session. The marks awarded for the project report shall be the same for all the batch mates.

SEE procedure for Project Work: SEE for project work will be conducted by the two examiners appointed by the HoD and BoE (Board of Examinations). The SEE marks awarded for the project work shall be based on the evaluation of project work Report, project presentation skill, and question and answer session.

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VIII SEMESTER

Sl. No.	Course	Course Code	Course Title	Teaching Department (TD) and Question Paper Setting Board (PSB)	Teaching Hours /Week				Examination				Credits
					Theory/ Lecturer	Tutorials	Practical / Drawing	SDA	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
1	OEC	22UMEXXXO	Open Elective Course - III (Online Courses)	online	3	0	0		03	50	50	100	3
2	AEC	22UMEXXXN	Ability Enhancement Course – III (Online Courses)	online	3	0	0		03	50	50	100	3
3	INT	22UME821I	Internship		0	0	10		03	100	100	200	10
								TOTAL	**09**	**200**	**200**	**400**	**16**

Open Elective Course - III [L-T-P::3-0-0]			
22UME811O	Fundamentals of Automotive systems (Available in NPTEL)	22UME812O	Computer Integrated Manufacturing (Available in NPTEL)
22UME813O	Product Design and Manufacturing (Available in NPTEL)	22UME814O	Business Planning & Project Management (Available in Swayam Portal)

Ability Enhancement Course - III [L-T-P::3-0-0]			

Swapping Facility

Students can swap VII and VIII Semester Scheme of Teaching and Examinations to accommodate **research internships/ industry internships** after the VI semester**.** Credits earned for the courses of VII and VIII Semester Scheme of Teaching and Examinations shall be counted against the corresponding semesters whether VII or VIII semester is completed during the beginning of IV year or later part of IV year of the program.

At the beginning of IV years of the program i.e., after VI semester, VII semester class work and VIII semester **Research Internship /Industrial Internship** shall be permitted to be operated simultaneously by the College so that students have ample opportunity for an internship. Research/Industrial Internship shall be carried out at an Industry, NGO, MSME, Innovation centre, Incubation centre, Start-up, Centre of Excellence (CoE), Study Centre established in the reputed research organizations/Institutes. The mandatory Research internship /Industry internship Internship is for 14 to 20 weeks. The internship shall be considered as a head of passing and shall be considered for the award of a degree. Those, who do not take up/complete the internship shall be declared to fail and shall have to complete it during the subsequent examination after satisfying the internship requirements.

Research internship: A research internship is intended to offer the flavor of current research going on in the research field. It helps students get familiarized with the field and imparts the skill required for carrying out research.

Industry internship: Is an extended period of work experience undertaken by students to supplement their degree for professional development. It also helps them learn to overcome unexpected obstacles and successfully navigate organizations, perspectives, and cultures. Dealing with contingencies helps students recognize, appreciate, and adapt to organizational realities by tempering their knowledge with practical constraints.

22UME 301 C	MECHANICS OF MATERIALS	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 100

Unit - I — 10 Hrs

Simple stress and strain: Introduction, stress, strain, mechanical properties of materials, Linear elasticity, Hooke's Law and Poisson's ratio, Stress-Strain relation – behavior in Tension for Mild steel and non ferrous metals. Extension / Shortening of a bar, bars with cross sections varying in steps, bars with continuously varying cross sections (circular and rectangular), Elongation due to self weight, Principle of super position.

Stress in composite section: Volumetric strain, expression for volumetric strain, elastic constants, simple shear stress, shear strain, temperature stresses (including compound bars).

UNIT - II — 10 Hrs

Compound stresses: Introduction, plane stress, stresses on inclined sections, principal stresses and maximum shear stresses, Mohr's circle (introduction).

Bending moment and Shear force in beams: Types of beams, loads and reactions, shear forces and bending moments, sign conventions, relationship between shear force and bending moments, shear force and bending moment diagrams for different beams subjected to concentrated loads, uniform distributed load (udl) and couple for different types of beams.

Unit - III — 10 Hrs

Thick and thin cylinders: Stresses in thin cylinders, changes in dimensions of cylinder (diameter, length and volume), Thick cylinders subjected to internal and external pressures (Lame's equation), (compound cylinders not included).

Bending and shear stresses in beams: Introduction, theory of simple bending, assumptions in simple bending, relationship between bending stresses and radius of curvature, relationship between bending moment and radius of curvature, shear streses, symmetrical I and T sections.

Unit - IV — 10 Hrs

Deflection of beams: Introduction, differential equation for deflection, equations for deflections-Cantilever subjected to concentrated load at free end, UDL,simply supported beam subjected to point load at mid-span.UDL.

Torsion of circular shafts and Elastic stability of columns: Introduction, pure torsion, assumptions, derivation of torsional equations, polar modulus, torsional rigidity / stiffness of shafts, power transmitted by solid and hollow circular shafts.

Introduction to columns, Euler's theory for axially loaded elastic long columns, derivation of Euler's load for various end conditions, limitations of Euler's theory, Rankine's formula.

Course Outcomes

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

CO1: Analyze the different types of physical loads, properties of the materials, such as stresses, strains, elasticity, deformation for varying cross section, compound bars, self-weight and thermal

stresses.

CO2: Analyze the compound stresses analytically, and graphically. And cylinders exposed to internal and external pressures from the view point of stresses developed and change in their dimensions.

CO3: Demonstrate the understanding of the shear force and bending moment and estimate bending of beams of subjected to different loads with different end conditions of beams. Analyse the bending and shear stresses for different cross sections.

CO4: Demonstrate the understanding of the concept torque, stresses developed and the rigidity of the mechanical elements transmitting power or subjected to twisting moment. Columns with different end conditions subjected to axial loading.

Reference Books:

1. "Strength of Materials", S.S.Bhavikatti, Vikas publications House – Pvt. Ltd., 2nd Ed., 2006.
2. "Mechanics of materials" R. C. Hibbeler, Printice Hall, Pearson Edu., 2005
3. "strength of material" by Dr.R.K.Bansal,Laxmi publications,fourth edition 2010.
4. "Mechanics of Materials" by K.V. Rao, G.C. Raju, First Edition,2007
5. "Mechanics of materials" James M. Gere, Thomson, Fifth edition 2004
6 "Mechanics of materials" Ferdinand Beer & Russell Johnstan, TATA MaGrawHill-2003.
7. "Mechanics of Materials" by H. J.Sawant,Technical publications,2010

*** Books to be listed as per the format with decreasing level of coverage of syllabus**

**** Each CO to be written with proper action word and should be assessable and quantifiable**

Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	3	3	2	3	1	-	-	-	2	1	-	2	-	-	-	-
CO2	3	3	2	2	1	-	-	-	1	2	-	2	-	-	-	-
CO3	3	3	1	3	1	-	-	-	2	1	-	2	-	-	-	-
CO4	3	3	1	2	1	-	-	-	2	1	-	2	-	-	-	-

22 UME 302 C	Manufacturing Process	04 - Credits
L:T:P - 3 : 0: 2		CIE Marks : 50
Total Hours/Week: 05		SEE Marks : 100

Unit - I — 10 Hrs

CASTING PROCESS

Introduction: Concept of Manufacturing process, its importance. Classification of Manufacturing processes.Introduction to Casting process &steps involved. Varieties of components produced by casting process.Advantages& Limitations of casting process.

Patterns: Definition, functions, Materials used for pattern, various pattern allowances and their importance, Classification of patterns.

Sand Moulding: Types of base sand, requirement of base sand. Moulding sand mixture ingredients for different sand mixtures. Method used for sand moulding, such as Green sand, dry sand and skin dried moulds.

UNIT - II — 10 Hrs

Cores: Definition, Need, Types. Method of making cores, Binders used, core sand moulding.

Concept of Gating & Risers: Principle and Elements of Gating System. Fettling and cleaning of castings. Basic steps, Casting defects,Causes, features and remedies**Moulding Machines:** Jolt type, Squeeze type, Jolt & Squeeze type and Sand slinger.

Special moulding Process: No bake moulds, Flask less moulds, Sweep mould, CO_2mould, Shell mould, Investment mould.

Metal moulds: Gravity die-casting, Pressure die casting, Centrifugal casting, Squeeze Casting, Slush casting and Continuous Casting Processes.

Unit - III — 10 Hrs

Forging:
Introduction, Merits, Different Smith forging operations, Forging defects.

WELDING

Welding process: Definition, Principles, Classification, Application, Advantages& limitations of welding.

Arc Welding: Principle, Metal Arc welding (MAW), Flux Shielded Metal Arc Welding (FSMAW), Inert Gas Welding (TIG & MIG) Submerged Arc Welding (SAW) and Atomic Hydrogen Welding processes (AHW).

Gas Welding: Principle, Oxy – Acetylene welding, Chemical Reaction in Gas welding, Flame characteristics. Gas torch construction &working. Forward and backward welding.

Unit - IV — 10 Hrs

Special types of welding: Resistance welding - principles, Seam welding, Butt welding, Spot welding and projection welding. Friction welding, Explosive welding, Thermit welding, Laser welding and Electron beamwelding.

Inspection Methods: Methods used for Inspection of casting and welding. Visual, Magnetic particle, Fluorescent particle, Ultrasonic, Radiography, Eddy current, Holography methods of Inspection.

Books:

1. Production engnineering I by Hajrachoudary
2. Manufacturing Process-I by Dr.K. Radhakrishna,Sapna Book House 5th Revised Edition 2009.
3. Manufacturing & Technology Foundry Forming and Welding by P.N.Rao, Tata McGraw Hill 3rd Ed., 2003
4. Manufacturing Technology by SeropeKalpakjian, Steuen. R. Sechmid Pearson Education Asia 5th Edition, 2006

Course Outcomes:

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

CO1: Select suitable manufacturing processes to manufacture the products optimally

CO2: Explain the technology, variables and complexity involved in producing a casting.

CO3: Analyze and access the importance of welding processes in manufacturing and apply knowledge to select appropriate welding process based on the type of industrial application

CO4:Interpret metallurgical aspects in welding, inspection methods for the quality assurance of components made of casting and welding process

PRACTICAL COMPONENT OF IPCC

Sl.NO	Experiments
1	Preparation of green sand moulds using two molding boxes kept ready for pouring. Using a.patterns (Single piece pattern and Split pattern) b.Without patterns. c.Incorporating core in the mould. (Core boxes).
2	Preparing minimum three forged models involving upsetting, drawing and bending operations.
3	Sand Tests a) Preparation of sand specimen b) Compression, Shear and Tensile tests on Universal Sand Testing Machine. c) Hardness Test d)Moisture Content test e)Sieve Analysis to find Grain Finest number of Base Sand
Demonstration only	
4	Preparation of one casting (Aluminium or cast iron)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other

assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.

- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.

- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for 25 marks.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted as per the scheduled timetable, with common question papers for the course (duration 03 hours)

i) Question paper consists of PART-A and PART-B.

ii) A total of 20 questions to be set in PART-A of each 1 mark or 10 questions of each 2 marks or a combination of 1 and 2 marks totaling to 20 marks, uniformly covering the entire syllabus. All questions in PART-A are mandatory.

iii) A total of eight questions to be set in PART-B with two from each unit uniformly covering the syllabus of the unit under consideration. Each question shall carry 20 marks. There shall be a maximum of four subdivisions in each question. Students have to answer one full question from each unit.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

ourse tcomes COs)	Programme Outcomes (POs)												Programme Specific Outcomes (Pso)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
1	3	2	1	-	-	1	1	-	-	-	-	-	2	2	1	2
2	2	3	1	-	-	1	1	-	-	-	-	-	2	3	1	1
3	3	1	2	1	-	1	-	-	-	-	-	-	2	1	2	1
4	2	2	2	2	-	1	1	-	-	-	-	-	3	1	1	1

22UME303C	**MATERIALS SCIENCE AND ENGINEERING**	**Credits: 04**
3-0-2		CIE Marks: 50
Total Hours/Week: 03		SEE Marks: 50

UNIT-I	**10 Hrs.**

Structure of Crystalline Solids

Fundaments concepts of unit cell, space lattice, unit cells for cubic structure BCC, FCC and HCP, coordination number and atomic packing factor for BCC, FCC and HCP structures. Determination of APF for different crystal structures. Crystal imperfections – point, line, surface and volume defects. Diffusion mechanism, Fick's laws of diffusion.

Concepts of stress and strain, tensile properties, Impact test of materials, Hardness – Rockwell, Vickers and Brinell hardness testing. Problems on true stress and true strain.

UNIT–II	**10 Hrs.**

Fatigue, Creep and Fracture

Fatigue: fracture tests, S-N curves, factors affecting fatigue life and protection methods. Creep: the creep curves, mechanism of creep, creep resistant materials. Types, stages in cup and cone fracture.

Solid solutions

Types, rules of governing the formation of solid solutions. Phase diagrams: basic terms, Gibbs phase rules, cooling curves, construction of phase diagrams, interpretation of equilibrium diagrams (use of tie line and Lever rule), types of phase diagrams (Eutectic systems, peritectic, eutectoid, peritectoid reactions). Problems on phase diagrams.

UNIT–III	**10 Hrs.**

Equilibrium phase Diagrams:

Iron – iron carbide equilibrium phase diagram, phases in Fe-Fe_3C system, invariant reactions, microstructure of slowly cooled steels, effect of alloying elements on Fe-Fe_3C diagram. The TTT diagrams, drawing of TTT diagrams, TTT diagrams for eutectoid steels, effect of alloying elements.

Heat Treatment:

Annealing, normalizing, hardening, Induction hardening, Carburizing, harden ability, Jominy end-quench test.

UNIT–IV	**xx Hrs.**

Engineering Alloys: **09 Hours**

Properties, composition and uses of low carbon, mild medium and high carbon steels, cast Irons, gray CI, white CI, malleable CI, SG iron. The light alloys, Aluminium alloys. Smart materials, types, uses.

Composite Materials:

Definition and classification of composites based on matrix and reinforcement, Characteristics of composite materials, Fibrous composites, Laminate composites and particulate composites.

Corrosion:

Corrosion and its prevention: Galvanic cell, the electrode potentials, polarization, passivation. General methods of corrosion prevention by alloying, stress corrosion cracking.

PRACTICAL COMPONENT OF IPCC	**09 hours**

1. Izod impact test
2. Charpy impact test
3. Brinell hardness test
4. Vickers hardness test
5. Rockwell hardness test
6. Tensile test
7. Compression test
8. Fatigue test
9. Study of microstructure of eutectoid, hypoeutectoid and hyper eutectoid steels

Reference Books *

1. "Introduction to Material Science for Engineering", 6th edition James F. Shackel ford. Pearson, Prentice Hall, New Jersy, 2006.
2. "Physical Metallurgy, Principles & Practices", V Raghavan.PHI 2nd Edition 2006, New Delhi.
3. "Foundation of Material Science and Engineering", Smith, 3rd Edition McGraw Hill, 1997.

Course Outcomes**

After completion of the course student will be able to

1. Calculate atomic packing factor of different crystal structures and determine the hardness, true stress and true strain.
2. Solve problems on phase diagrams and interpret the phase diagrams. Analyse various modes of failures in materials.
3. Synthesize heat treated ferrous metal by annealing and normalizing and illustrate iron – iron carbide equilibrium and non equilibrium phase diagrams.
4. Illustrate the composition and properties of various engineering alloys, smart materials, composite materials and the process of corrosion, its causes and preventive methods.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks if He/She secured 22 marks in CIE). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **20 marks** for two Internal Assessment Tests (Two Tests, each of 20 Marks with 01.5 hour duration, are to be conducted) and **10 marks** for other assessment methods. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **30 marks** for the conduction of the experiment and preparation of laboratory record, and **20 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **30 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **20 marks.**
- Scaled-down marks of the sum of term work and laboratory CIE marks will be the laboratory component of IPCC (that is for **25 marks)**.

The student has to secure 40% of 25 marks to qualify in the CIE of the laboratory component of IPCC.

Question Paper Pattern for theory SEE

1. Part A: All the questions are compulsory. One mark or two marks questions for 20 marks covering the entire syllabus.
2. Part B: Any four full questions choosing one question from each unit for 80 Marks.

* **Books to be listed as per the format with decreasing level of coverage of syllabus**

**** Each CO to be written with proper action word and should be assessable and quantifiable**

Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	2	1		1						1		1	2	1		1
CO2	2	2		2						1		1	2	2		2
CO3			1	2						1		1			1	2
CO4		1	1							1		1		1	1	

22UME 304C	ENGINEERING THERMODYNAMICS	03 - Credits
L:T:P -3 : 0: 0		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

Work & Heat: Definition of work-according to mechanics, according to thermodynamics, examples, sign convention; Displacement work- PdV expressions for displacement work in various processes through p-v diagrams, Other types of work- Shaft work, paddle wheel work, work in straining a bar, free expansion work, electrical work; Heat- definition, units and sign convention; Comparison and differences between work and heat. Numerical Problems

First Law of Thermodynamics: Joule's experiments; Statement of the First law of thermodynamics- cyclic, non-cyclic processes; Energy- modes of energy, internal energy, internal energy as a property; Specific heat- at constant volume, at constant pressure; Enthalpy; Extension of the First law to control volume- steady state-steady flow energy equation, important applications with line diagram. Numerical Problems.

UNIT – II	10 Hrs

Second Law of Thermodynamics: Energy- High grade, low grade; Heat reservoirs-heat source and heat sink; Heat engines-definition, schematic representation, thermal efficiency; Reversed heat engines-refrigerator, heat pump, COP; Second Law of Thermodynamics- Kelvin -Planck statement, PMM II, Clasius's statement; Equivalence of the two statements; Reversible and irreversible processes- definition, factors that make a process reversible and irreversible; Carnot cycle- processes involved in Carnot cycle, PV, TS and line diagram; Carnot principles; Thermodynamic temperature scale. Numerical Problems.

Gas Power Cycles: Air standard cycles- Carnot, Otto, Diesel, Dual and Stirling cycles, PV and TS diagrams, description / process, efficiency derivation, mean effective pressure derivation, comparison of Otto, Diesel and dual cycles; **Numerical Problems**.

UNIT - III	10 Hrs

Combustion Thermodynamics: Combustion- complete, incomplete; Air for combustion- theoretical, excess, problems;; problems; Enthalpy of formation – definition, determination of enthalpy of formation of compounds using tables, enthalpy and internal energy of combustion, **Numerical problems**; Combustion efficiency; Adiabatic flame temperature.

I.C. Engines: Geometrical properties of reciprocating engines; Performance parameters - indicated work, BP, IP, MEP, SFC, SEC, A/F ratio, equivalence ratio, efficiencies (mechanical, thermal / fuel conversion, volumetric), engine specific weight, engine specific volume, relationship between performance parameters; engine design and performance data analysis; Dynamometer -definition, types (Rope break and eddy current), description; Methods of FP calculation; Measurement of fuel consumption and air consumption; Heat balance sheet; **Numerical problems**.

UNIT IV	10 Hrs

Reciprocating Compressors: Air Compressor terminology; Operation of a single stage reciprocating air compressor; Work input of single stage- without clearance, representation on PV diagram for different processes, work done derivation for different process; Work input of single stage- with clearance, PV diagram, effect of clearance volume and volumetric efficiency; Adiabatic, isothermal and mechanical efficiencies; Multi-stage compressor- saving in work, optimum intermediate pressure, inter-cooling, minimum work for

compression; **Numerical problems on single stage only**.

Refrigeration: Vapour compression refrigeration system- dry compression, wet compression, superheated & sub cooling compression, their PH, TS diagram, description/process, analysis, refrigerating effect, capacity, power required, COP; Air cycle refrigeration- reversed Carnot cycle, analysis for non flow system and flow system; Reversed Brayton cycle- analysis as flow system; **Numerical Problems**

Reference Books:

1. B.K.Venkanna,2010, Basic Thermodynamics(2 nd edition),PHI learning
2. B.K.Venkanna,2012,Applied Thermodynamics(2 nd),PHI learning
3. Rajaput,2007, Engineering Thermodynamics (2 nd),Laxmi Publications

Question paper pattern for SEE:

1. Part A: One - two marks questions covering entire syllabus for 20 marks (compulsory).
2. Part B: Four units, each unit carrying 2 questions of 20 marks each.
3. Students need to answer 4 full questions selecting one from each unit.

Course Outcomes:

After completion of the course student will be able to

CO1: Define the concepts of heat, work, and energy, develop/analyze energy application device Demonstrate a basic understanding of the First Law of Thermodynamics for energy conservation analysis of different thermodynamics processes of systems and control volumes and to estimate required balances of heat, work and energy flow (heaters, coolers, pumps, turbines, pistons, etc…

CO2: Demonstrate a basic knowledge of the Second Law of Thermodynamics and its corollaries to determine whether a cycle is possible, and to determine the maximum performance/efficiency of cycles and its application to systems and control volumes.

CO3: To write/compute stoichiometric balance chemical reactions, calculate equivalence ratios, estimate energy transfer associated with combustion problems. Analyze the performance (BP, IP, BSFC, ISFC, BSEC, BTE, ITE, Volumetric efficiency, Mechanical Efficiency,) /heat balance sheet of internal

CO4: Do thermodynamic analysis (single and multi-stage, single acting and double acting) of reciprocating compressor and optimize the power in put calculation compare and discuss single and double acting, single and multi-stage performance data. Understand the components and basic assumptions for the vapor-compression refrigeration system, demonstrate the ability to design thermodynamic cycle and to perform analysis of reversed Carnot cycle based, refrigeration and heat pump cycles using various working fluids.

*** Books to be listed as per the format with decreasing level of coverage of syllabus**

**** Each CO to be written with proper action word and should be assessable and quantifiable**

Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	3	3	2	-	2	2	-	-	-	-	-	-	1	1	1	-
CO2	3	2	3	-	2	1	-	-	-	-	-	-	0	1	1	-
CO3	3	2	3	-	3	-	-	-	1	-	-	-	0	1	1	-
CO4	2	1	1	-	2	1	-	-	1	-	-	1	0	1	1	-

22 UME 311 L	Mechanical Drawing and G.D & T Lab	Credits: 02
L:T:P - 0 : 0 : 4		CIE Marks: 50
Total Hours/Week: 20		SEE Marks: 50

PART-A	10 Hrs.

Drafting

- Dimensioning and Tolerance
- Surface finish, Conventions, Abbreviations and Symbols
- Applications of GD & T in Engineering practice
- Sections of solids, Orthographic conversion (Miscellaneous Problems)
- Component drawing reading 3 examples

PART-B	10 Hrs.

Assembly Drawing (Any one)

- Valves • Plummer block

Free hand sketching of the following (Any Two)

- Carburetor • Fuel pump • Differential, Power transmission
- Couplings • Screw jack • Knuckle joint

Reference Books *

1. K. R. Gopalakrishna, (Aug-2017), Machine Drawing (23rd edition), Subhas Publications
2. N. D. Bhatt, (Jan-2014), Machine Drawing, (50th Edition), Charotar publishing house, Pvt. Ltd.
3. K L Narayana, P Kannaiah and K Venkata Reddy (2006), Machine Drawing, (3rd edition), New Age Publications

Course Outcomes**

After completion of the course student will be able to

1. Proficient in using engineering drawing instruments, materials and techniques
2. Draw freehand sketches, orthographic projections, and use of surface texture symbols and dimensioning styles in the drawing
3. Create drawings to industrial standard and draw the assembly from the individual part drawing
4. Familiar with freehand sketching, conventions used in engineering drawing, geometrical dimensioning and tolerance etc

*** Books to be listed as per the format with decreasing level of coverage of syllabus**
**** Each CO to be written with proper action word and should be assessable and quantifiable**

Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-

22 UME 312 L	SPREADSHEETS FOR ENGINEERS	Credits: 01
L:T:P - 1 : 2 : 0		CIE Marks: 50
Total Hours/Week: 20		SEE Marks: 50

PART-A	10 Hrs.

Introduction to Excel

About Excel & Microsoft, Uses of Excel, Excel software, Spreadsheet window pane, Title Bar, Menu Bar, Standard Toolbar, Formatting Toolbar, the Ribbon, File Tab and Backstage View, Formula Bar, Workbook Window, Status Bar, Task Pane, Workbook & sheets

Columns & Rows

Selecting Columns & Rows, Changing Column Width & Row Height, Autofitting Columns & Rows, Hiding/Unhiding Columns & Rows, Inserting & Deleting Columns & Rows, Cell, Address of a cell, Components of a cell – Format, value, formula, Use of paste and paste special

Functionality Using Ranges

Using Ranges, Selecting Ranges, Entering Information Into a Range, Using AutoFill

Creating Formulas

Using Formulas, Formula Functions – Sum, Average, if, Count, max, min, Proper, Upper, Lower, Using AutoSum,

Advance Formulas

Concatenate, Vlookup, Hlookup, Match, Countif, Text, Trim

Spreadsheet Charts

Creating Charts, Different types of chart, Formatting Chart Objects, Changing the Chart Type, Showing and Hiding the Legend, Showing and Hiding the Data Table

Data Analysis

Sorting, Filter, Text to Column, Data Validation

PivotTables Creating PivotTables, Manipulating a PivotTable, Using the PivotTable Toolbar, Changing Data Field, Properties, Displaying a PivotChart, Setting PivotTable Options, . Adding Subtotals to PivotTables

Spreadsheet Tools

Moving between Spreadsheets, Selecting Multiple Spreadsheets, Inserting and Deleting Spreadsheets Renaming Spreadsheets, Splitting the Screen, Freezing Panes, Copying and Pasting Data between Spreadsheets, Hiding , Protecting worksheets

Experiments

1 Charting: Create an XY scatter graph, XY chart with two Y-Axes, add error bars to your plot, create a combination chart

2 Functions: Computing Sum, Average, Count, Max and Min, Computing Weighted Average, Trigonometric Functions, Exponential Functions, Using The CONVERT Function to Convert Units

3 Conditional Functions: Logical Expressions, Boolean Functions, IF Function, Creating a Quadratic Equation Solver, Table VLOOKUP Function, AND, OR and XOR functions.

4 Regression Analysis: Trendline, Slope and Intercept, Interpolation and Forecast, The LINEST Function, Multilinear Regression, Polynomial Fit Functions, Residuals Plot, Slope and Tangent, Analysis Tool Pack.

5 Iterative Solutions Using Excel: Using Goal Seek in Excel, Using The Solver To Find Roots, Finding Multiple Roots, Optimization Using The Solver, Minimization Analysis, Non Linear Regression Analysis. ○ **6 Matrix Operations Using Excel:** Adding Two Matrices, Multiplying a Matrix by a Scalar, Multiplying Two Matrices, Transposing a Matrix, Inverting a Matrix and Solving System of Linear Equations.

*** Books to be listed as per the format with decreasing level of coverage of syllabus**

**** Each CO to be written with proper action word and should be assessable and quantifiable**

Course Outcomes	**Programme Outcomes (POs)**												**Program Specific Outcomes (PSOs)**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-

22UME401C	THEORY OF MACHINES	03 - Credits
L:T:P - 3 : 0: 0		CIE Marks : 50
Total Hours: 40		SEE Marks : 50

UNIT – I	10 Hrs

INTRODUCTION: Link or element, kinematic pairs, degrees of freedom, Grubler's criterion (without derivation), Kinematic chain, Mechanism, structure, Mobility of Mechanism, Inversion, Machine. kinematic chains and inversions: Inversions of Four bar chain; Single slider crank chain and Double slider crank chain.

MECHANISMS: Quick return motion mechanisms -Drag link mechanism, Whitworth mechanism and Crank and slotted lever Mechanism. Straight line motion mechanisms – Peaucellier's mechanism and Robert's mechanism. Intermittent Motion mechanisms – Geneva mechanism and Ratchet and Pawl mechanism. Toggle mechanism, Pantograph, Ackerman steering gear mechanism.

UNIT – II	10 Hrs

STATIC FORCE ANALYSIS: Introduction: Static Equilibrium. Equilibrium of Two and Three Force Members. Members with Two Forces and Torque, Free Body Diagrams, Principle of Virtual Work. Static Force Analysis of Four Bar Mechanism and Slider-Crank Mechanism with and without friction.

BALANCING OF ROTATING MASS: Static and Dynamic Balancing, Balancing of Single Rotating Mass by Balancing Masses in Same plane and in Different planes. Balancing of Several Rotating Masses by Balancing Masses in Same plane and in Different planes.

UNIT – III	10 Hrs

GOVERNORS: Types of Governors: Force Analysis of Porter and Hartnell Governors. Controlling Force,Stability,Sensitiveness,Isochronism,Effort and Power

GYROSCOPE: Vectorial Representation of Angular Motion, Gyroscopic Couple. Effect of Gyroscopic Couple on Ship, Plane Disc, Aeroplane, Stability of Two Wheelers and Four Wheelers.

UNIT – IV	10 Hrs

GEAR TRAINS: Simple gear trains, Compound gear trains for large speed reduction, Epicyclic gear trains, Algebraic and tabular methods of finding velocity ratio of epicyclic gear trains. Tooth load and torque calculations in epicyclic gear trains.

CAMS: Types of cams, Types of followers, Displacement, Velocity and Acceleration time curves for cam profiles. Disc cam with reciprocating follower having knife -edge, roller and flat-faced follower, Disc cam with oscillating roller follower, Follower motions including SHM, Uniform velocity, uniform acceleration and retardation and Cycloidal motion.

Reference Bok:

1. Theory of Machines, Rattan S.S. McGraw-Hill Education, 2nd edition, 2005.
2. Theory of Machines, Sadhu Singh Pearson Education (Singapore) Pvt. Ltd., Indian Branch, New Delhi, 2nd edition, 2006.
3. Theory of Machines & Mechanisms, Shigley. J. V. and Uickers, J. OXFORDUniversity press.J, 3rd edition 2004
1. Theory of Machines, Robert L. Norton, McGraw-Hill Higher Education, 3rd edition 2006

Course Outcomes:

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

CO1: Construct or Compose mechanisms to provide specific motion.
CO2: Apply the concepts of forces acting on the mechanisms.
CO3: Analyze the effect of a gyroscopic couple on Ship, Aeroplane and an Automobile.
CO4: Analyze the concepts of gear trains and construct cam profile for the specific follower motion.

Question paper pattern for SEE:

1. Total of eight questions with two from each unit to be set uniformly covering the entire syllabus.
2. Each question should not have more than four subdivisions.
3. Any five full questions are to be answered choosing at least one from each unit.

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	2	2	2	-	1	-	-	1	-	-	-	1	2	2	-	-
CO2	2	2	3	-	1	-	-	1	-	-	-	1	2	2	-	-
CO3	3	2	3	-	1	-	-	1	-	-	-	1	2	2	-	-
CO4	3	2	3	-	1	-	-	1	-	-	-	1	2	2	-	-
	High -3, Medium – 2, Low - 1															

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22UME402C	**Metal Cutting and Metrology**	**Credits: 04**
3-0-2		CIE Marks: 50
Total Hours: 40		SEE Marks: 50

UNIT-I	**10 Hrs.**

Cutting Tools

Single point cutting tool nomenclature, geometry, orthogonal and oblique cutting, mechanism of chip formation, types of chips, shear angle relationship, Merchants circle diagram and analysis (Relation of orthogonal cutting forces), Ernst Merchant's solution, stress and strain in the chip, power and energy relations in metal cutting, problems of Merchant's analysis, tool wear and tool failure, tool life, effects of cutting parameters on tool life, tool failure criteria, causes of wear, Taylor's tool life equation, problems on tool life evaluation.

Cutting Tool Materials

Desired properties, selection of tool materials, types of cutting tool materials. Cutting fluids, desired properties, types and selection. Heat generation in metal cutting, factors affecting heat generation, heat distribution in tool and work piece, measurement of tool tip temperature.

UNIT–II	**10 Hrs.**

Machine Tools

Classification and constructional features and machining operations on turning, drilling, shaping, planning, milling and grinding machines ((No sketches of machine tools, sketches
to be used only for explaining the operations).

Machining time

Evaluation of machining time and metal removal rate (MRR) for various operations carried on Lathe, Shaper,Planer and Drilling machine.

Indexing

Definition, methods and numericals on Indexing

UNIT–III	**10 Hrs.**

STANDARDS OF MEASUREMENT: (10 Hrs)

Definition and Objectives of metrology, Standards of length - International prototype meter, Imperial standard yard, subdivision of standards, line and end standard, comparison, transfer from line standard to end standard, calibration of end bars (Numerical), Slip gauges, Wringing phenomena, Indian Standards (M-87, M-112), Numerical problems on building of slip gauges.

SYSTEM OF LIMITS, FITS, TOLERANCES AND GAUGING:

Definition of tolerance, Specification in assembly, Principle of inter changeability and selective assembly limits of size, Indian standards, concept of limits of size and tolerances, compound tolerances accumulation of tolerances, definition of fits, types of fits and their designation (IS 919 - 1963), geometrical tolerance, positional - tolerances, hole basis system, shaft basis of system, classification of gauges, numerical on shaft and hole basis systems. Types of gauges -plain plug gauge, ring gauge,
snap gauge, gauge materials.

UNIT–IV	10 Hrs.

MEASUREMENTS AND MEASUREMENT SYSTEMS:
Introduction to generalised measurement systems, Significance of measurement.

MEASUREMENT OF FORCE AND TORQUE, PRESSURE:
Principle, analytical balance, proving ring, Torque measurement, Prony brake, hydraulic dynamometer. Pressure Measurements, Principle, use of elastic members, Bridgeman gauge, Mcloed gage, Pirani Gauge.

TEMPERATURE AND STRAIN MEASUREMENT:
Resistance thermometers, thermocouple, law of thermocouple materials used for construction, pyrometer, Optical Pyrometer. Strain Measurements, Strain gauge, methods of strain measurement.

PRACTICAL COMPONENT OF IPCC	10 hours

Part – A

1. Preparation of three models on lathe involving Facing, Plain turning, Step turning ,Taper turning, Knurling , Thread cutting.
2. Demonstration of cutting of V / Rectangular groove using Shaping.

Part – B

3. Calibration of Pressure Gauge
4. Calibration of Torque sensor
5. Calibration of LVDT
6. Calibration of Load cell
7. Calibration of micrometer using slip gauges
8. Calibration of speed sensor

Reference Books *

1. Workshop Technology Vol-II by Hazara Choudhry, Media Promoters andPublishers Pvt. Ltd. 14, 2014 .
2. Production Technology by R.K.Jain Khanna Publications, 2003.
3. Productiontechnology by HMT Tata MacGraw Hill, 2001.
4. ManufacturingScience by Amitabha Ghosh and Mallik, Affiliated East West Press, 2003.
5. Production Technology by P. C. Sharma, S. Chand & Company Pvt.Ltd., 8, 2014.
6. Fundamentals ofMachining and Machine Tools by G. Boothroyd,Winston A. Knight, Marcel Dekker, INC, 2, 2005.
7. Production Engineering by P. C. Pandey, Standard PublishersDistributors, 10, 2016.
8. Engineering Metrology by R. K. Jain, Khanna Publishers, 1994.
9. Measurement Systems Applications and Design, by Ernest O, Doeblin, McGraw Hill Book Co.
10. Engineering Metrology by R. K. Jain Khanna Publishers, 1994.

Course Outcomes**

After completion of the course student will be able to

1. **Identify proper cutting tool material and metal cutting operation on the basis of shape and size of the raw material and determine machining time and metal removal rate (MRR) of Lathe, Shaper, Planer and Drilling machine.**
2. **Analyze tool wear mechanisms and equations to enhance tool life and minimize machining cost.**
3. **Measure precise machine elements by calibrating line standards using end standards, slip gauges M45, M87 and M112 set and designing limits and fits.**
4. **Apply the knowledge of calibrated measuring instruments to measure various entities namely, temperature, pressure, force, torque and strain.**

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks if He/She secured 22 marks in CIE). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **20 marks** for two Internal Assessment Tests (Two Tests, each of 20 Marks with 01.5 hour duration, are to be conducted) and **10 marks** for other assessment methods. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **30 marks** for the conduction of the experiment and preparation of laboratory record, and **20 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **30 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be

conducted for 50 marks and scaled down to **20 marks.**

- Scaled-down marks of the sum of term work and laboratory CIE marks will be the laboratory component of IPCC (that is for **25 marks)**.

The student has to secure 40% of 25 marks to qualify in the CIE of the laboratory component of IPCC.

Question Paper Pattern for theory SEE

3. Part A: All the questions are compulsory. One mark or two marks questions for 20 marks covering the entire syllabus.
4. Part B: Any four full questions choosing one question from each unit for 80 Marks.

*** Books to be listed as per the format with decreasing level of coverage of syllabus**

**** Each CO to be written with proper action word and should be assessable and quantifiable**

Course Outcomes	**Programme Outcomes (POs)**												**Program Specific Outcomes (PSOs)**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
CO1	**2**	**1**		**1**						**1**		**1**	**2**	**1**		**1**
CO2	**2**	**2**		**2**						**1**		**1**	**2**	**2**		**2**
CO3			**1**	**2**						**1**		**1**			**1**	**2**
CO4		**1**	**1**							**1**		**1**		**1**	**1**	

22UME 403C	Fluid Mechanics	04 - Credits
L:T:P: 03:00:02		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

Properties of Fluids:
Introduction, properties of fluids, viscosity, thermodynamic properties, surface tension and capillarity, vapour pressure and cavitation. Numerical problems.

Fluid Statics:
Fluid pressure at a point, Pascal's law, pressure variation in a static fluid, Absolute, gauge, atmospheric and vacuum pressures, single manometers, differential manometers, total pressure and center of pressure, vertical plane surface submerged in liquid, horizontal plane surface submerged in liquid, inclined plane surface submerged in liquid, curved surface submerged in liquid. Buoyancy, center of buoyancy, metacenter and metacentric height, conditions of equilibrium of floating and submerged bodies. Numerical problems

UNIT – II	10 Hrs

Fluid Kinematics:
Types of fluid flow, Introduction, continuity equation, continuity equation in three dimensions (Cartesian co-ordinate system only), velocity and acceleration, velocity potential function and stream function. Numerical problems.

Dimensional Analysis:
Introduction, derived quantities, dimensions of physical quantities, dimensional homogeneity, Buckingham's ∏ theorem, Raleigh's method, dimensionless numbers, similitude, types of similitude. Numerical problems.

UNIT - III	10 Hrs

Fluid Dynamics:
Introduction, equations of motion, Euler's equation of motion, Bernoulli's equation from Euler's equation, Bernoulli's equation for real fluids. Numerical problems.

Fluid flow measurements:
Introduction, venturimeter, orifice meter, Pitot tube. Discharge over rectangular and triangular notches. Numerical problems.

Flow through pipes:
Frictional loss in pipe flow, Darcy- Equation for loss of head due to friction in pipes, Chezy's equation for loss of head due to friction in pipes, hydraulic gradient and total energy line. Minor loses in pipes - Sudden enlargement, sudden contraction, obstruction, bend, elbow. Numerical problems.

UNIT IV	10 Hrs

Laminar flow and viscous effects:
Reynold's number, critical Reynold's number, laminar flow through circular pipe -Hagen-Poiseulle's equation, Laminar flow between parallel stationery plates. Numerical problems.

Flow past immersed bodies:
Drag, Lift, expression for lift and drag, pressure drag and friction drag, boundary layer concept, displacement thickness, momentum thickness and energy thickness. Numerical problems.

Introduction to compressible flow:
Velocity of sound in a fluid: velocity of sound in terms of bulk modules, velocity of sound for isothermal process, velocity

of sound for adiabatic process.
Mach number: Subsonic, sonic and supersonic flows, propagation of disturbance for different Mach numbers, Mach cone.
Stagnation properties: Stagnation pressure, stagnation temperature, area velocity relationship for compressible flows.

PRACTICAL COMPONENT OF IPCC	06 Hrs

1. Determination of coefficient of discharge of Venturimeter
2. Determination of coefficient of discharge of Orifice meter
3. Determination of head loss due to friction (Major losses)
4. Determination of head due to sudden contraction, sudden enlargement, bend and elbow(Minor losses)
5. Determination of coefficient of discharge of V-notch.
6. Determination of coefficient of impact of jet.

REFERENCE BOOKS

1. Fluid Mechanics, Bansal.R.K, New Delhi Lakshmi Publications, Fifth Edition 2016.
2. Fluid Mechanics (SI Units), Yunus A. Cingel and J. M. Cimbala. Tata McGraw-Hill, second edition, 2008
3. Fluid Mechanics and hydraulics, Dr. Jagadishlal: New Delhi Metropolitan Corporation, Eight Edition, 1985.
4. Fluid Mechanics, John F.Douglas, Janul and M.Gasiosek and John A. Swaffield, Pearson New Delhi, Fifth Edition, 2008.
5. Fluid Mechanics and Fluid Power Engineering," Kumar.D.S, New Delhi, Kataria and Sons,2009.
6. 1000 Solved problems in Fluid Mechanics by Subramanya K, New Delhi, TMH, 2007.

After completion of the course student will be able to

CO1: *Classify* the types of fluids and *calculate* shear stress, pressure intensity, total pressure, centre of pressure, metacentre and metacentric height.

CO2: *Differentiate* between the types of fluid flow, similitude and *calculate* the velocity and acceleration aspects in a fluid flow *applying* continuity equation and dimensional analysis.

CO3: *Evaluate* the velocity as well as theoretical discharge using flow meters and losses in a pipes and conduits by *applying* Bernoulli's, Euler's, Darcy-Weisbach and Chezy's equations.

CO4: *Differentiate* between the viscous and compressible flows and *evaluate* the pressure loss, lift and drag and velocity of sound in a fluid flow.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks if He/She secured 22 marks in CIE). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.

- 25 marks for the theory component are split into **20 marks** for two Internal Assessment Tests (Two Tests, each of 20 Marks with 01.5 hour duration, are to be conducted) and **10 marks** for other assessment methods. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **30 marks** for the conduction of the experiment and preparation of laboratory record, and **20 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **30 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **20 marks.**
- Scaled-down marks of the sum of term work and laboratory CIE marks will be the laboratory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the laboratory component of IPCC.

Question Paper Pattern for theory SEE

5. Part A: All the questions are compulsory. One mark or two marks questions for 20 marks covering the entire syllabus.
6. Part B: Any four full questions choosing one question from each unit for 80 Marks.

Course Outcomes (COs)	Programme Outcomes (POs)															
	PO1	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	PSO 3	PSO 4
1	2	1	-	1	-	-	-	-	1	-	-	1	1	1	-	-
2	2	1	-	1	-	-	-	-	1	-	-	1	1	1	-	-
3	2	1	-	1	-	-	-	-	1	-	-	1	1	1	-	-
4	2	1	-	1	-	-	-	-	1	-	-	1	1	1	-	-

22UME404 C	Industrial Management & Entrepreneurship	Credits: 03
L:T:P - 3 : 0: 0		CIE Marks: 50
Total Hours/Week: 40		SEE Marks: 50

UNIT-I	10 Hrs.

Management: Introduction, Meaning, nature and characteristics of Management, Scope and Functional areas of management, Management as a science, art of profession, Roles of Manager, Levels of Management, Development of Management Thought: early management approaches.

Planning: Nature, importance and purpose of planning process, Objectives, Types of plans (Meaning only), Importance of planning – steps in planning & planning premises.

UNIT–II	10 Hrs.

Organizing And Staffing: Nature and purpose of organization, Principles of organization, Types of organization, Departmentation, Committees, Nature and importance of staffing, Process of Selection & Recruitment (in brief).

Motivation And Behavior: Hawthorns studies and its findings, Maslow's theory of needs, X-Theory and Y-Theory, Immaturity theory motivation hygiene theory, McClelland"s theory of motivation.

UNIT–III	10 Hrs.

Directing & Controlling: Meaning and nature of directing, Leadership styles, Communication: Meaning and importance, Coordination: meaning and importance and Techniques of Co–Ordination. Controlling: Meaning and steps in controlling, Essentials of a sound control system, Methods of establishing control (in brief).

Entrepreneur: Meaning of Entrepreneur, Functions of an Entrepreneur, Types of Entrepreneur (only types), Role of entrepreneurs in Economic Development, Entrepreneurship in India, Entrepreneurship: its Barriers.

UNIT–IV	10 Hrs.

Small Scale Industries (SSI): Definition, Characteristics, Need and rationale, Objectives, Scope, Role of SSI in economic development. Advantages of SSI, Steps to start a SSI, Government policy towards SSI, Different Policies of SSI, Government Support for SSI during 5-Year plans. Supporting Agencies of Government for SSI, Meaning, Nature of support, Objectives and Functions (brief).

Quality Philosophy: The Meaning of Quality and Quality Improvement, Brief History of Quality Methodology, Statistical Methods for Quality Control and Improvement.

Reference Books *

4. Harold Koontz, (2010), Essentials of Management, (Eighth edition), Tata McGraw-Hill
5. Poornima M. Charantimath, (2015), Entrepreneurship Development and Small Business Enterprises, (Third edition), Pearson Education India
6. Harold Koontz, Cyril O'Donnell, (2018), Principles of Management, (Fifth edition), McGraw Hill
7. P. C. Tripathi and P. N. Reddy, (2012), Principles of Management (Fifth edition), Tata McGraw Hill
8. Douglas C. Montgomery, (2019), Introduction to Statistical Quality Control (Eighth edition), Wiley international

Course Outcomes**

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

CO1	Demonstrate the ability of understanding, the nature, purpose, evolution, patterns of management. Analyze the purpose of planning, distinguish different plans and able to describe the detailed process of planning.
CO2	Identify and apply the nature and purpose of organizing, Departmentation, Staffing, Human factors and motivation.
CO3	Express the need of Leadership, concepts of directing and controlling, Demonstrate the importance of

	Entrepreneurship, role of Entrepreneur, Characteristics, and Classification of Entrepreneurs.
CO4	Develop the knowledge of small-scale industries, characteristics, role, and government support and quality philosophy.

After completion of the course student will be able to

1. Understand the concept of management, organization, planning, staffing
2. Understand the importance of Directing and controlling, leadership styles, Communication, Coordination and Controlling
3. Understand the role of entrepreneurs in economic development, and barriers, Identification of business opportunities, feasibility studies
4. Understand IPRs, Five-Year plans and institutional support in entrepreneurship

*** Books to be listed as per the format with decreasing level of coverage of syllabus**

**** Each CO to be written with proper action word and should be assessable and quantifiable**

Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	-
CO3	1	-	-	-	-	2	2	-	-	3	1	-	-	1	1	-
CO4	1	-	-	-	-	2	2	-	-	-	-	1	1	2	1	-

22UME409L	IV Semester CAMD LAB	02 - Credits
L:T:P - 0 : 0: 4		CIE Marks : 50
Total Hours /Week: 2		SEE Marks : 50

Part – A	5 Hrs
Orthographic views: Conversion of pictorial views into orthographic projections of simple machine parts with or without section. (Bureau of Indian Standards conventions are to be followed for the drawings) Hidden line conventions. Precedence of lines.	
PART - B	**6 Hrs**
Keys, Joints & Couplings: Riveted Joints, Parallel key, Taper key, Feather key, Gibhead key and Woodruff key. Flanged coupling and universal coupling (Hooks' Joint)	
PART - C	**9 Hrs**
Assembly Modeling and Drafting (Part drawings should be given) Any four 1. Plummer block (Pedestal Bearing) 2. I.C. Engine connecting rod 3. Screw jack (Bottle type) 4. Tailstock of lathe 5. Machine vice 6. Tool Head of shaper	
Reference Books: 1. 'A Primer on Computer Aided Machine Drawing-2007', Published by VTU, Belgaum. 2. 'Machine Drawing', N.D.Bhat& V. M. Panchal 3. 'Machine Drawing' , N. Siddeshwar, P. Kanniah, V.V.S. Sastri,published by Tata Mc GrawHill,2006 4. 'A Text Book of Computer Aided Machine Drawing', S. Trymbaka Murthy, CBS Publishers, New Delhi, 2007 5. 'Machine Drawing' , K.R. Gopala Krishna, Subhash Publication.	
Question paper pattern for SEE: 1. Each laboratory subject is evaluated for 100 marks (50 CIE and 50 SEE). 2. The CIE in laboratory in classes is carried out for 50 marks (30 marks for the performance and term work) 3. For remaining 20 marks one practical test to be conducted. The SEE practical is conducted for 50 marks two questions to be set from each Part A/Part B (05 marks drawing + 15 marks for CAD printout) and Part C (05 Marks manual drawing + 20 Marks assembly model + 05 Assembly Printout) [20+30=50] No Viva voce **Note: There is no Theory Examination. Examination is only for CAMD Laboratory.**	
Laboratory Assessment: 1. Each laboratory subject is evaluated for 100 marks (50 CIE and 50 SEE). 2. The CIE in laboratory in classes is carried out for 50 marks (30 marks for the performance and term work) 3. For remaining 20 marks one practical test to be conducted for sketching and printouts from SOLID EDGE.	

The SEE practical is conducted for 50 marks of three hour duration one question to be set from Part A or Part B and one assembly question from Part C. Student has to answer all the question. Part A or Part B for 20 marks and Part C for 30 marks.

Course Outcomes

CO1: Summarize the sketching, navigational, modeling, assembly commands used in SOLID EDGE software.

CO2: Predict the conversion of pictorial views into orthographic projections of simple machine parts with or without section.

CO3: Model solid models (3D drawings) of machine parts like joints and couplings

CO4: Analyze and assemble the machine components and convert to 2D drawings in assembly or in single unit.

CO5: Employ the information prepared by industry/customer to construct functioning of the mechanical system

Course Outcomes	Programme Outcomes (POs)												Program Specific Outcomes (PSOs)			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	1	-	-	-	2	-	-	-	-	-	-	1	1	-	-	1
CO2	1	-	-	-	2	-	-	-	-	-	-	1	1	-	-	1
CO3	1	-	-	-	2	-	-	-	-	-	-	1	1	-	-	1
CO4	1	-	-	-	2	-	-	-	-	-	-	1	1	-	-	1
CO5	1	-	-	-	2	-	-	-	-	-	-	1	1	-	-	1

21UME 501 C	V SEM DESIGN OF MACHINE ELEMENTS	03 - Credits (3: 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 100

Unit - I — 10 Hrs

INTRODUCTION

Definitions: Normal, Shear, Biaxial and Triaxial Stresses, Stress Tensor, Principal Stresses
Engineering Materials and their Mechanical properties, Stress-Strain diagrams, Stress Analysis, Design considerations: Codes and Standards.

DESIGN FOR STATIC STRENGTH

Static loads and Factor of Safety, Theories of failure. Maximum Normal Stress Theory, Maximum Shear Stress Theory, Distortion Energy Theory Failure of Brittle Materials, Failure of Ductile Materials, Stress Concentration, Determination of Stress Concentration Factor.

UNIT - II — 10 Hrs

Design for Fatigue strength

Design For Fatigue Strength: Introduction- S-N Diagram, Low Cycle Fatigue, High Cycle Fatigue, Endurance Limit, Endurance Limit Factors: Size effect, Surface effect, Stress Concentration effects. Fluctuating Stresses, Goodman and Soderberg relationship, Stresses due to Combined Loading, Cumulative Fatigue Damage.

Design of Threaded Fasteners:

Stresses in Threaded Fasteners, Effect of Initial Tension, Design of Threaded Fasteners under Static, Dynamic and Impact loads, Design of Eccentrically loaded Bolted Joints.

Unit - III — 10 Hrs

Design of Shafts and Keys:

Torsion of Shafts, Design for strength and Rigidity with Steady loading, ASME & BIS codes for Power Transmission shafting, Shafts under Fluctuating loads and Combined loads. Design of rectangular and square keys

Unit - IV — 10 Hrs

Design of Springs

Definitions, Types of springs, Stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, springs under fluctuating loads, Energy stored in springs, Torsion, Belleville and Rubber springs. Leaf Springs: Stresses in leaf springs. Equalized stresses,

Design of Spur Gears:

Spur Gears: Definitions, Stresses in gear tooth: Lewis equation and form factor, Design for strength, Dynamic load and wear load.

Text-books:

1. Design of Machine Elements V.B. Bhandari Tata McGraw Hill Publishing Company Ltd2nd Edition/ 2007
2. Design of Machine Elements S. C. Sharma PHI Learning Pvt. Ltd 01-Jan-2002

Reference books:

1. Machine Design: Robert L. Norton Pearson Education Asia, 2001
2. Design of Machine Elements: M. F. Spotts, T. E. Shoup, L. E. Hornberger, Pearson Education 2006
3. Fundamentals of Machine Component Design Robert C. Juvinall and Kurt M Marshek, Wiley India Pvt. Ltd., New Delhi, 3rd Edition, 2007
4. Mechanical Engineering Design Joseph E Shigley and Charles R. Mischke. McGraw Hill International edition, 6th Edition 2003

Course Outcomes:

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

CO 1. Explain the terminologies and preliminary concepts related to Normal, shear, biaxial, tri axial and Principal

stresses, stress-strain diagram, codes and standards.

CO 2. Apply the concepts of stress analysis, theories of failure and material science to analyze, design and/or select commonly used machine components.

CO 3. Apply different theories to the design of shafts subject to combined static and dynamic loads

CO 4. Analyze and design of springs for various loadings and applications

CO 5. Analyze and design of spur gears for various loadings and applications

Question paper pattern:

- Part A is compulsory covering the entire syllabus and carries 20 marks either one mark or two mark questions
- Part B: Total of eight questions with two from each unit to be set uniformly covering the entire syllabus.
- Each question carries 20 marks and should not have more than 4 subdivisions.
- Any four full questions are to be solved choosing at least one from each unit.

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
1	3	2	2	3	2				2			
2	3	2	2	2								
3	3	3	2	2	2				2			
4	3	2	2	2					2			
5	3	2	2	2					2			
	High -3, Medium – 2, Low - 1											

21UME 502 C	V SEM ENERGY CONVERSION TECHNOLOGY	03 - Credits (3: 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 100

Unit - I — 10 Hrs

INTRODUCTION:

04 Hours

Definition of turbomachine, Parts of a turbo machine, Comparison with positive displacement machine, Classification of turbomachines, Application of dimensional analysis to turbomachines and their physical significance, specific speed for power absorbing and power developing machines, Numerical problems on dimensional analysis and model studies.

ENERGY TRANSFER IN TURBOMACHINES:

06 Hours

Euler turbine equation, Alternate form of Euler turbine equation, Components of energy transfer, Degree of reaction, General analysis of a turbo machine, Effect of blade discharge angle on energy transfer and degree of reaction, General analysis of turbines (axial flow machines), Utilization factor, Relation between utilization factor and degree of reaction, Condition for maximum efficiency, Condition for maximum utilization factor, Optimum blade speed ratio and maximum energy transfer, Numerical problems on above topics

UNIT - II — 10 Hrs

PUMPS AND COMPRESSORS: **04 Hours**

General analysis of centrifugal pumps and compressors, Effect of blade discharge angle, Analysis on performance, Theoretical head capacity relationship, Centrifugal machines stage parameters, Work done, Power, Stage pressure rise, Degree of reaction, Numerical problems on above topics.

CENTRIFUGAL PUMPS:

06 Hours

Working principle, Main parts of a centrifugal pump, Classification, Head, Static head, Manometric head, Pump Efficiencies, Manometric, Mechanical, Hydraulic, Volumetric and Overall efficiency; Work done by the pump, Pressure rise in a pump, Minimum starting speed, Multistage pumps; Cavitation, Numerical problems on above topics.

Unit - III — 10 Hrs

STEAM AND GAS TURBINES: **04 Hours**

Impulse staging and need for compounding, Compounding, Velocity, Pressure, Velocity and pressure compounding, Impulse turbine, Performance parameters, Effects of friction and blade angles on blade efficiency, Condition for maximum efficiency, Maximum efficiency and work done, Numerical problems on above topics.

MULTISTAGE IMPULSE TURBINE (TWO STAGE):

02 Hours

Work done, Blade efficiency, Condition for maximum efficiency, Maximum blade efficiency, Maximum work done, Maximum utilization factor with equiangular blades, Numerical problems on above topics.

REACTION TURBINES:

04 Hours

Degree of reaction, Condition for maximum efficiency (without carry over efficiency), Maximum efficiency, Maximum work done, Utilization for factor, Condition for maximum utilization factor, Maximum utilization factor, Blade design parameters, Numerical problems on above topics.

Unit - IV

10 Hrs

HYDRAULIC TURBINE: **05 Hours**

Unit quantities, Terminology,Pelton Wheel, Velocity triangle, Power developed, Hydraulic efficiency, Condition for maximum hydraulic efficiency, Maximum hydraulic efficiency, Turbine efficiency, Hydraulic, Mechanical, Volumetric and Overall efficiency, important design parameters. Numerical problems on above topics.

FRANCIS AND KAPLAN TURBINES: **05 Hours**

Velocity triangle, Runner shapes for different blade speeds (blade angles), Design parameters, Draft tube and types draft tubes, functions of a draft tube, Efficiency of a draft tube, Kaplan and Propeller turbines, Velocity triangles, Design parameters, Numerical problems on above topics.

Reference Books:

1. Principles of Turbomachinery, D.G.Shephered, The Macmillan Company, Newyork, 1964.
2. An Introduction to energy Conversion - Volume III – Turbo machinery, A. Kadambi and Manohar Prasad, New Age International publishers, 1977.
3. Turbines, Compressors and Fans, S.M.Yahya, Tata McGraw Hill Company ,2nd Edition, 2002.
4. Gas Turbine Theory, H.Cohen, GFC Rogers and HIH Saravanamuttoo, Thomson Press (India) Ltd. 4th Edition, 1998.
5. Gas Turbines, V.Ganeshan, Tata Mc Graw Hill, 2nd edition, 2002.
6. A Treatise on Turbo machines, G.Gopalaksrihsna and D. Prithiviraj, Scitech Publications (India) PVT., Limited, 2002.
7. Text book of Turbomachines, By M.S. Govindegowda and A.M. Nagaraj, M.M.Publishers, Davangere, Karnataka.

Course Outcomes:

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

CO1: *Apply* the knowledge of turbo machinery terminology to *develop* governing equation for rotating machinery and classify the rotating machines.
CO2: *Apply* the knowledge of turbo machinery to *analyze* the power absorbing turbomachine (Centrifugal machines)
CO3: *Apply* the knowledge of turbo machinery to analyze the impulse and reaction steam turbines.
CO4: *Apply* the knowledge of turbo machinery to analyze the water turbines (Pelton, Francis and Kaplan water turbines)

Question paper pattern:

- Part A is compulsory covering the entire syllabus and carries 20 marks either one mark or two mark questions
- Part B: Total of eight questions with two from each unit to be set uniformly covering the entire syllabus.
- Each question carries 20 marks and should not have more than 4 subdivisions.
- Any four full questions are to be solved choosing at least one from each unit.

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	3	2	1	1	1	2	1	3	3	1	1	2
2	3	2	1	1	1	2	1	3	3	1	1	2
3	3	2	1	1	1	2	1	3	3	1	1	2
4	3	2	1	1	1	2	1	3	3	1	1	2
	High -3, Medium – 2, Low - 1											

21UME 503 C	V SEM HEAT TRANSFER	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 100

Unit - I — 10 Hrs

INTRODUCTION:
03 Hours
Modes of heat transfer, Basic laws governing conduction, convection, and radiation heat transfer,Combined heat transfer mechanism, Overall heat transfer coefficient, Boundary conditions of 1st, 2nd and 3rd Kind. Mathematical formulation of heat conduction problems.

CONDUCTION:
02 Hours
Derivation of general three-dimensional heat conduction equation in Cartesian coordinate system, Special cases, 3-D conduction equation in cylindrical and spherical coordinate systems (No derivation).

STEADY STATE HEAT CONDUCTION
05 Hours Derivation for heat flow and temperature distribution in a plane wall, Hollow cylinder and hollow sphere without heat generation, Thermal resistance concept & its importance. Composite wall, cylinder and sphere, Contact resistance, Critical thickness of insulation without heat generation, Heat transfer in extended surfaces of uniform cross-section without heat generation, Long fin, Tip insulated fin and fin with heat transfer from the tip, Fin efficiency and effectiveness, Numerical problems on above topics.

UNIT - II — 10 Hrs

TRANSIENT HEAT CONDUCTION: **02 Hours**
Conduction in solids with negligible internal temperature gradient (Lumped system analysis), Use of Transient temperature charts (Heisler's charts) for slab, long cylinder and sphere, Numerical Problems
.

CONCEPTS AND BASIC RELATIONS IN BOUNDARY LAYERS:
04 Hours
Flow over a body, Velocity and thermal boundary layer,Critical Reynolds number,General expressions for drag coefficient and drag force,General expression for local heat transfer coefficient, Average heat transfer coefficient, Nusselt number, Flow inside a duct- velocity boundary layer, Hydrodynamic entrance length and hydro dynamically developed flow, Numerical problems based on empirical relations given in the data handbook.

FREE OR NATURAL CONVECTION:
04 Hours
Application of dimensional analysis for free convection, Physical significance of Grashoff number, Use of correlations of free convection for vertical, horizontal and inclined flat plates, Vertical and horizontal cylinders and spheres, Numerical problemsbased on empirical relations given in the data handbook.

Unit - III — 10 Hrs

FORCED CONVECTION:
05 Hours
Application of dimensional analysis for forced convection, Physical significance of Reynolds, Prandtl, Nusselt and Stanton numbers, Use of various correlations for hydro dynamically and thermally developed flow inside a duct, Use of correlations for flow over a flat plate, cylinder and sphere. Numerical problemsbased on empirical relations given in the data handbook.

HEAT EXCHANGERS: **05 Hours**
Classification of heat exchangers, Overall heat transfer coefficient, Fouling and fouling factor, LMTD analysis of heat exchangers, Effectiveness-NTU methods of analysis of heat exchangers. Numerical problemsbased on

empirical relations given in the data handbook.

Unit - IV **10 Hrs**

RADIATION HEAT TRANSFER:
06 Hours
Thermal radiation, Definitions of various terms used in radiation heat transfer, Stefan-Boltzmann law, Kirchhoff's law, Planck's law and Wien's displacement law. Radiation heat exchange between two parallel infinite black surfaces, Configuration factor or view factor, Intensity of radiation and solid angle; Lambert's law, Radiation heat exchange between two parallel infinite gray surfaces, Effect of radiation shield (only discussion on nonblack surfaces), Numerical problems based on empirical relations given in the data handbook.

CONDENSATION AND BOILING:
04 Hours
Types of condensation (discussion only), Nusselt theory for laminar condensation on a vertical flat surface (no derivation), Use of correlations for condensation on vertical flat surfaces, Horizontal tube and horizontal tube banks, Reynolds number for condensate flow, Regimes of pool boiling, Pool boiling correlations,Numerical problemsbased on empirical relations given in the data handbook.

Reference books:

1. Heat Transfer– A Basic approach, M. Necati Ozisik, Tata Mc Graw Hill International ed. 1998
2. Heat Transfer – A Practical approach, Yunus A. Cenegal , Tata Mc Graw Hill, 2002.
3. Heat Transfer, J.P.Holman, Tata Mc Graw Hill, 9th edition, 2008.
4. Principles of Heat Transfer, Kreith, Thomson learning , 2001.
5. Fundamentals of Heat and Mass transfer , Frank P. Incropera and David P. Dewitt , John Wiley and Sons, 4th ed. 1995
6. Heat transfer, P.K. Nag , Tata Mc Graw Hill, 2002.
7. **Heat and Mass Transfer data handbook:** C.P. Kothandaraman and S. Subramanya, New Age International Publishers, 9th Ed. 2018.

Course Outcomes:

Course Outcomes: At the end of the course student will be able to
Course Outcomes: At the end of the course student will be able to
CO1: *Apply* the knowledge of heat transfer to *analyze* unidirectional conduction heat transfer problems.
CO2: *Apply* the knowledge of transient heat transfer to *analyze* time dependent heat transfer problems and fluid flow fundamentals to natural and forced convection heat transfer problems.
CO3: *Apply* the knowledge of heat transfer fundamentals to *analyze* forced convection and heat exchanger problems.
CO4: *Apply* the knowledge of heat transfer fundamentals to *analyze* radiation and phase change heat transfer problems.

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	3	2	1	1	1	2	1	3	3	1	1	2
2	3	2	1	1	1	2	1	3	3	1	1	2
3	3	2	1	1	1	2	1	3	3	1	1	2
4	3	2	1	1	1	2	1	3	3	1	1	2
	High -3, Medium – 2, Low – 1											

21UME 504 L	V Semester	01 - Credits (0 : 0 : 2)

Hrs./Week : 02	FLUID MECHANICS AND MACHINERY LAB	CIE Marks : 50
Total Hours : 20		SEE Marks : 50

Part – A	10 Hrs

Calibration of flow measuring device: (any 3)

a. Orifice plate
b. Flow nozzle
c. Venturimeter
d. Rotameter
e. V- Notch
f. Determination of co efficient of friction of flow through pipe
g. Determination of minor losses (Sudden Expansion, Sudden Contraction, Bend and Elbow) in flow through pipes.
h. Determination of force developed by impact of jets on vanes

PART - B	10 Hrs

Group experiments

a. Performance testing of turbines
b. Pelton wheel,
c. Francis turbine
d. Kaplan turbine
e. Performance testing of pumps
   Single stage and multi stage centrifugal pump
   Reciprocating pump
   Performance test on two/single stage reciprocating air compressor
   Performance test on air blower

Scheme for Examination:

One Question from Part A - 15 Marks (05 Writeup+10)
One Question from Part B - 25 Marks (05 Writeup+20)
Viva-Voce - 10 Marks

Total 50 Marks

21UME 516 H	V SEMESTER	03 - Credits (3 : 0 : 0)

Hrs./Week : 03	**MANAGEMENT & ENTREPRENEURSHIP**	CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	**10 Hrs**

Management: Introduction, Meaning, nature and characteristics of Management, Scope and Functional areas of management, Management as a science, art of profession, Roles of Manager, Levels of Management, Development of Management Thought: early management approaches.

Planning : Nature, importance and purpose of planning process, Objectives, Types of plans (Meaning only), Importance of planning – steps in planning & planning premises

UNIT – II	**10 Hrs**

Organizing and Staffing: Nature and purpose of organization, Principles of organization, Types of organization, Departmentation, Committees, Nature and importance of staffing, Process of Selection & Recruitment (in brief).

Motivation and Behavior: Hawthorns studies and its findings, Maslow's theory, X and Y theory, Immaturity theory motivation hygiene theory, McClelland"s theory of motivation.

UNIT - III	**10 Hrs**

Directing & Controlling: Meaning and nature of directing, Leadership styles, Communication: Meaning and importance, Coordination: meaning and importance and Techniques of Co–Ordination. Controlling: Meaning and steps in controlling, Essentials of a sound control system, Methods of establishing control (in brief).

Entrepreneur: Meaning of Entrepreneur, Functions of an Entrepreneur, Types of Entrepreneur (only types), Role of entrepreneurs in Economic Development, Entrepreneurship in India, Entrepreneurship: its Barriers.

UNIT IV	**10 Hrs**

Small Scale Industries: Definition, Characteristics, Need and rationale, Objectives, Scope, role of SSI in Economic Development. Advantages of SSI Steps to start and SSI, Government policy towards SSI, Different Policies of SSI, Government Support for SSI during 5 year plans. Supporting Agencies of Government for SSI, Meaning, Nature of support, Objectives, Functions (brief).

Quality Philosophy: The Meaning of Quality and Quality Improvement, Brief History of Quality Methodology, Statistical Methods for Quality Control and Improvement

Reference Books:

1. Principles of Management, P.C.Tripathi, P.N.Reddy – Tata McGraw Hill,
2. Management and Entrepreneurship, Kanishka Bedi Oxford University Press, 4th edition 2009
3. Principles of Management, Harold Koontz, Cyril O'Donnell McGraw Hill Create 5th edition 2018
4. Principles of Management, Koontz O Donnel, Mc.Graw Hill Intl. Book Co.
5. Statistical Quality Control, E.L. Grant and R.S. Leavenworth, 7thEdition, McGraw- Hill publisher
6. Entrepreneurship Development – Poornima.M.Charantimath –Small Business Enterprises – Pearson Education – 2006 (2 & 4).

Course Outcomes:

At the end of the course student will be able to

CO1: Demonstrate the ability of understanding, the nature, purpose, evolution, patterns of management. Analyze the purpose of planning, distinguish different plans and able to describe the detailed process of planning.

CO2: Identify and apply the nature and purpose of organizing, Departmentation, Staffing, Human factors and motivation.

CO3: Express the need of Leadership, concepts of directing and controlling demonstrate the importance of Entrepreneurship, role of Entrepreneur, Characteristics, and Classification of Entrepreneurs.

CO4: Develop the knowledge of small-scale industries, characteristics, role, and government support and quality philosophy.

Question paper pattern for SEE:

1. Total of eight questions with two from each unit to be set uniformly covering the entire syllabus.
2. Each question carries 20 Marks and should not have more than 4 subdivisions
3. Any five full questions are to be answered choosing at least one from each unit.

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
1	1	1	---	---	---	---	---	---	2	1	2	1
2	---	1	---	---	---	---	---	---	---	---	---	1
3	---	1	---	---	---	---	---	---	3	1	---	1
4	---	---	---	---	---	---	---	---	---	1	1	1
	High -3, Medium – 2, Low - 1											

21UME 537 N	**V SEMESTER** **Product Design & Rapid Prototyping** **Open elective 2023-24 (odd)**	**03 - Credits (3 : 0 : 0)**
Hrs./Week : 03		**CIE Marks : 50**
Total Hours : 40		**SEE Marks : 100**

Course Outcomes:

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

1. Learning basics of product design as a means to manage the development of an idea from concept through to production
2. Analyse ,evaluate and apply the generic method for product development
3. Learning basics of prototyping
4. Demonstrate Stereolithogrphy , selective laser sintering , fused deposition modeling , laminated object manufacturing & solid ground curing

Unit - I **10 Hrs**

Introduction : Definition , importance of PD, Objectives of PD,essential requirements of PD, who designs product, Project team, steps in new PD, Characteristics of successful product development, duration and cost of product development , challenges of product development, Design for manufacture, remanufacturing , sequential and concurrent engineering .

Design for manufacture & assembly: Design for Manufacture and Assembly, History , Implementation of Design for Assembly , Design for Manufacture , How Does DFMA Work, Advantages of Applying DFMA during Product Design design for Maintainability, Design for Environment Design for safety, Vision and Illumination design

UNIT - II **10 Hrs**

Development processes and organizations :A generic development process,Usefulness of a well-defined Development Process, task & responsibilities for marketing, design and manufacturing , concept development: the front end process, adopting the generic product development process, process flow diagram for variant of products, product development organizations (functional, project & matrix)

Unit - III **10 Hrs**

Introduction: Prototype fundamentals,definition of Prototypes, types of prototypes, need for the compression in product development, RP fundamentals , RP wheel, history of RP systems, applications of RP, growth of RP industry, basic principle of rapid prototyping processes, classification of RP systems . advantages and disadvantages of rapid prototyping

Stereolithogrphy systems: principle, process details , advantages and disadvantages, applications

Unit - IV **10 Hrs**

Selective Laser sintering: principle, process details , advantages and disadvantages, applications

Fused deposition modeling: principle, , process details , advantages and disadvantages, applications

Laminated object manufacturing : principle, process details, LOM materials advantages and disadvantages, applications

Solid Ground curing: principle of operation , machine details, advantages and disadvantages, applications

Text-books:

1. Product design & development by Karl T Ulrich and Steven D Eppinger
2. Rapid Prototyping principles and applications by C K Chua, K F Leong and C S Lim

Reference books:

- The design of everyday things by Don Norman

- Product designs from concept to Manufacture by Jennifer Hudson
- Additive manufacturing by Brent Stucker, David W. Rosen, and lan Gibson
- Engineering design and rapid prototyping by Ali K. Kamrani and EmadAbouel Nasr

Course Outcomes:

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

CO1: Learning basics of product design as a means to manage the development of an idea from concept through to production

CO2: Analyse ,evaluate and apply the generic method for product development

CO3: Learning basics of prototyping

CO4: Demonstrate Stereolithogrphy , selective laser sintering , fused deposition modeling, laminated object manufacturing & solid ground curing

Scheme of Examination:

Student has to solve PART-A compulsorily and from PART-B any ONE full question from each of the four UNITS.

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
1	1	2			3	1	1	1	1		1	
2	3	2	3		1	2		1	1	2	1	1
3	1	1	2	1	3	3		1	2	1	1	1
4	3	2	3	2	3	1	1		1	1	1	
	High -3, Medium – 2, Low - 1											

21UME 538 N	V SEMESTER OPERATION RESEARCH	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 100

Unit - I	2+9 Hrs

INTRODUCTION **02 Hours**

Definition, scope of Operations Research (OR) approach and limitations of OR Models, Characteristics and phases of OR

LINEAR PROGRAMMING PROBLEMS

09 Hours Linear programming, graphical method, simplex method, Two-phase method, duality theory, dual simplex method.

UNIT - II	6+4Hrs

TRANSPORTATION PROBLEMS

06 Hours

Mathematical model for Transportation problem, balanced and unbalanced transportation problem. Methods to solve transportation problem, finding basic feasible solution, testing solution for optimality

ASSIGNMENT PROBLEMS

04 Hours

Formulation, unbalanced assignment problem, travelling salesman problem

Unit - III	4+5 Hrs

SEQUENCING

04 Hours

Johnson's algorithm, n - jobs to 2 machines, n - jobs 3machines, n -jobs m machines without passing sequence. 2 jobs n machines with passing. Graphical solutions priority rules.

PERT-CPM TECHNIQUES:

05 Hours

Project network construction, Critical Path Method (CPM), determination of critical path, Project Evaluation and Review Technique (PERT), probability of completing a project in a scheduled date.

Unit - IV	5+5 Hrs

GAME THEORY

05 Hours

Laws of Probability, Formulation of games, two people-Zero sum game, games with and without saddle point, Graphical solution (2x n, m x 2 game), and dominance property.

REPLACEMENT MODELS **05 Hours**

Introduction, replacement of items whose maintenance and repair costs increase with time, ignoring changes in the value of money during the period, replacement of items whose maintenance costs increase with time and value of money also changes with time, replacement of items that fail suddenly, group replacement policy.

REFERENCE BOOKS:

1. Operation Research AM Natarajan, P. Balasubramani, A Tamilaravari Pearson 2005
2. Operations Research, S. D. Sharma, Kedarnath Ramanath and Co, 2002
1. Operations Research, Prem Kumar Gupta, D S Hira, 3rd Edition, S Chand and Company Ltd., New

Delhi, 2008.

2. Operations Research, S Kalavathy 4th Edition
3. Operations Research, Panneerselvam R, Prentice – Hall of India, New Delhi, 2002

Course Outcomes:

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

CO 1. To have the knowledge about role of operations research in formulating the problem and solution to by mathematical model for the areas of production, distribution of goods and economics etc.

CO 2. To understand variety of other problems of operations research like assignment, transportation, travelling salesman etc.

CO 3. To identify the resources required for a project and generate a plan and use CPM and PERT techniques, to plan, schedule, and control project activities.

CO 4. To solve the game theory problems for the conflicts situation management and know the replacement policies of varied items**.**

Scheme of Examination:

Student has to solve PART-A compulsorily and from PART-B any ONE full question from each of the four UNITS.

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
1	1	2			3	1	1	1	1		1	
2	3	2	3		1	2		1	1	2	1	1
3	1	1	2	1	3	3		1	2	1	1	1
4	3	2	3	2	3	1	1		1	1	1	
	High -3, Medium – 2, Low - 1											

UME704C	VII SEMESTER FINITE ELEMENT METHODS	03 - Credits (2 : 2 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

Introduction: Equilibrium equations in elasticity subjected to body force, traction forces, stress strain relations for plane stress and plane strain, Boundary conditions, Initial conditions, Euler's Lagrange's equations of bar, beams, Principle of a minimum potential energy, principle of virtual work, Rayleigh-Ritz method Galerkins method and Matrix techniques .

Basic Procedure: General description of Finite Element Method, , Discretization process; types of elements 1D, 2D and 3D elements, size of the elements, location of nodes, node numbering scheme, half Bandwidth, Stiffness matrix of bar element by direct method, Properties of stiffness matrix, Preprocessing, post processing. Engineering applications of finite element method. Advantages & Disadvantages of FEM.

UNIT – II	10 Hrs

Interpolation Models: Polynomial form of interpolation functions- linear, quadratic and cubic, Simplex, Complex, Multiplex elements, Selection of the order of the interpolation polynomial, Convergence requirements , static condensation. penalty approach and elimination method.

One Dimensional Bar Element: Recall of 1D linear bar element. Lagrangian interpolation, Higher order one dimensional elements- quadratic, Cubic element and their shape functions, properties of shape functions, Effect of temperature on 1D elements and stress calculation.

UNIT – III	10 Hrs

Two Dimensional Elements: Shape functions and stiffness matrix of 2D elements four-Node quadrilateral, Nine-Node quadrilateral Eight-Node quadrilateral, serendipity and lagrange comparison with 2D pascals triangle. CST and LST shape functions, jacobian matrix , stiffness matrix, force terms, stress calculation and Numerical integration. Introduction to 3-D elements shape function of tetrahedron element

UNIT – IV	10 Hrs

Trusses and Beam Elements: Analysis of trusses and beam elements its shape functions, stiffness matrix and stress calculation

Heat Transfer Problems: Steady state heat transfer, 1D heat conduction governing equation, boundary conditions, One dimensional element, Functional approach for heat conduction, Galerkin approach for heat conduction, heat flux boundary condition, 1D heat transfer in thin fins

Reference Books:

1. The FEM its basics and fundamentals: O. C. Zienkiewicz, Elsevier, 9e. 2018
2. Finite Element Method, J. N. Reddy, McGraw –Hill International Edition.
3. Finite Element Methods, by Daryl. L. Logon, Thomson Learning 5td edition, 2010.
4. Finite Element Analysis, by H.V. Lalshminarayana, Universities press, 2004.
5. Finite Elements in engineering, Chandrupatla T.R., 3rd Pearson Edition. 2018
6. Finite Element Analysis, C. S. Krishnamurthy,–Tata McGraw Hill Publishing Co. Ltd, New Delhi, 2017.
7. "Fundamental Finite Element Analysis and Application" by "Asghar Bhatti" by PageTurner 2018.
8. "Advanced Topics in Finite Element Analysis of Structures with Mathematica and MATLAB Computations" by M. Asghar Bhatti by PageTurner 2017.

Course Outcomes:

1. Generate the governing FE equations for engineering problems /Mechanical systems.
2. Apply FEM to solve bars subjected to static load and thermal load
3. Apply the concept of lagrange interpolation for 2D and 3D elements and solve
4. Apply FEM to solve trusses and beam problems

Question paper pattern for SEE:

1. Total of eight questions with two from each unit to be set uniformly covering the entire syllabus.
2. Each question carries 20 Marks and should not have more than 4 subdivisions
3. Any five full questions are to be answered choosing at least one from each unit.

Table: Matrix to describe the mapping of Pos with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
1	1	1	1	1	1	--	--	--	--	--	--	--
2	2	1	2	1	3	--	--	--	--	--	--	--
3	2	1	2	1	3	--	--	--	--	--	--	--
4	2	1	2	1	3	--	--	--	--	--	--	--

UME 732 E	NON DESTRUCTIVE TESTING	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

Introduction to ND Testing: Information gathered from NDT, Defects in manufacturing Advantages and disadvantages of NDT, Comparison of destructive & Non-destructive tests, Methods of NDT, Common application of NDT, Flaw detection & evaluation, leak detection & evaluation, Non Destructive Evaluation, visual inspection
Replication microscopy technique for Non Destructive Evaluation: Specimen preparation, replication techniques, and micro structural analysis

UNIT – II	10 Hrs

Liquid Penetrant Inspection: Principles, penetrant methods, procedure, materials used,equipment, parameters and applications Magnetic Particle Inspection: Principle, general procedure, advantages & limitations , applications , magnetic field generation, types of magnetic particles and suspension liquids,
Direction of the Magnetic Field ,Importance of Magnetic Field Direction

UNIT - III	10 Hrs

Radiography Inspection: principle, X-ray radiography, equipment, Gamma-ray radiography, real time radiography & film radiography , radiation safety ,advantages, disadvantages and applications of radiography Computed tomography: Principles, capabilities, comparison to other NDE methods, CT
equipments, industrial computed tomography applications

UNIT IV	10 Hrs

Ultrasonic Inspection: Basic equipment, advantages & limitations, inspection methods pulse echo A, B, C scans transmission transducers & couplants Thermal Inspection: Principles, equipment, inspection methods applications Eddy Current Inspection: Principles of operation, procedure, advantages & limitations, operating variables, inspection coils, eddy current instruments, application examples

Reference Books:

1. NON DESTRUCTIVE EVALUTION AND QUALITY CONTROL, METALS HAND BOOK, AMERICAN SOCIETY OF METALS, 9TH , EDITION 2001
2. NON DESTRUCTIVE –GARDEN AND REACH, MC GONNAGLE JJ NEWYORK

Course Outcomes: By the end of course with aid of design data handbook students shall be able to,

1. To have a basic knowledge of surface N D E techniques which enable to carry out various inspection in accordance with the established procedures.
2. Differentiate various defect types and select the appropriate N D T methods for better evaluation
3. Documentation of the testing and evaluation of the results for further analysis
4. Students will be able to understand significance and suitability of various non destructive testing methods in industrial application.

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
1	3	1	--	3	2	--	3	1	3	1	--	3
2	2	1	--	1	1	--	2		3	--	--	3
3	3	--	--	2	--	1	1	2	2	--	--	2
4	1	2	1	2	--	--	--	1	--	2	1	1

UME 716 E	ADVANCED MANUFACTURING TECHN0LOGY	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs
Introduction: Introduction to CAD/CAM, product system facilities: Low, medium and high. Manufacturing support systems, Automation in production systems. Automated manufacturing systems. Computerized manufacturing systems. Reasons for automating, Automation principles and strategies. Discussions. **Fundamentals of Automated Production Lines:** Introduction, System configurations, Workpart transfer mechanisms, Storage buffers, Control of the production line.	
UNIT – II	**10 Hrs**
Analysis of Transfer Lines: Analysis of Transfer Lines with no internal storage: Basic terminology and Performance measures, Workstation breakdown analysis: Upper bound approach, Lower bound approach, and Analysis of Transfer Lines with storage buffers. Numerical examples. **Automated Assembly System:** Introduction, System configurations, Parts delivery at workstations, Applications. Quantitative analysis: Parts delivery system, Multi-station and single station assembly machines. Partial automation.	
UNIT - III	**10 Hrs**
NC Part Programming: Basic components of an NC system, EIA and ISO coding standards, NC part programming exercises. **Computer Assisted Part Programming:** Defining part geometry**,** Specifying tool path and operation sequence, Computer task in computer-assisted part programming, Part programming with APT exercises.	
UNIT IV	**10 Hrs**
Product Life Cycle Management: Introduction, Product information, PLM framework, Benefits, Implementation, Enabling technologies, Example of business problem. Product data management: Evolution of PDM systems, Scope, Benefits, Implementation, Software capabilities, software functions. **Advances in Automated Factory:** Industry 4.0**:** functions, applications and benefits, Components of Industry 4.0, Internet of things (IoT), IoT applications in manufacturing, Big-Data and cloud computing for IoT, IoT for smart manufacturing	
Reference Books: 1. Groover M. P., Automation, Production Systems and CIM, Prentice Hall of India, 2008. 2. Ibrahim Zeid, Mastering CAD/CAM, Tata McGraw Hill, 2008. 3. P. N. Rao, CAD/CAM Principles and Applications, 2nd Edition 4. Computer Integrated Manufacturing, Bharat Vijamuri, Sunstar Publisher, 4th Edition, 2018. 5. Industry 4.0 Google Search on the content	
Course Outcomes: At the end of the course student will be able to 1. Read and demonstrate good comprehension of study of two aspects of production systems and how they are sometimes automated and /or computerized in modern industrial practice. 2. will demonstrate the ability to • Apply basic methods of examination of the technology of automated production lines and develop several mathematical models that can be used to analyze their operation. • Use of mechanized and automated devices to perform the various assembly tasks in an assembly line or cell. 3. will demonstrate the ability to • Evaluate, integrate, and apply programmable automation in which the mechanical actions of	

the machine tool or other equipment are controlled by a program containing coded alphanumeric data.

4. will be able to
    - Properly understand PLM; why it is crucial for companies to implement, what a PLM system offers, what PDM is and its relationship to PLM.
    - Study the functions and components, applications and benefits of Industry 4.0, Concept of IoT.

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	**Programme Outcomes (POs)**											
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
1	--	2	2	1	2	1	--	--	--	2	1	--
2	2	--	1	1	1	--	2	1	--	--	--	--
3	--	1	2	1	1	3	--	1	2	2	1	1
4	--	--	2	3	1	1	--	--	2	1	1	--

UME 712 E	COMPOSITE MATERIALS	03 - Credits (2 : 2 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

Introduction to composite materials:
Definition and classification of composites based on matrix and reinforcement, Characteristics of composite materials, Fibrous composites, Laminate composites and particulate composites. Factors which determine the properties of composites, Benefits of composites, properties and types of reinforcements and matrices, Reinforcement-matrix interface.

UNIT – II	10 Hrs

Polymer matrix composites:
Introduction, Polymer matrices, Processing methods like Layup and curing, open and closed mold process- hand layup techniques, laminate bag molding, production procedures for bag molding, filament winding, pultrusion, pulforming, thermo forming, molding methods, properties of PMCs
and applications, Some commercial PMCs.

UNIT - III	10 Hrs

Metal matrix composites:
Introduction, Metallic matrices, Classification of MMCs, Need for production of MMCs, Interface reactions, processing methods like Powder metallurgy, diffusion bonding, Melt stirring, Compo/Rheo casting, Squeeze casting, Liquid melt infiltration, Spray deposition and In situ Processes, Properties of metal matrix composites, Applications, Some commercial MMCs.

UNIT IV	10 Hrs

Mechanics of composite materials :
Continuous fibers, Iso-stress condition, Iso-strain condition, critical volume fraction of fiber and minimum volume fraction o fiber, Numericals on modulus of rigidity, and mechanics of discontinuous fibers, stress Vs strain curves for PMCs, MMCs, and CMCs. Cutting and machining of composites: Reciprocating knife cutting, cutting of cured composite, Joining of composites: Mechanical fastening, Adhesive bonding.

Reference Books:

1) MeingSchwaitz, “Composite materials hand book”, McGraw Hill Book Company. 1984
2) Composite Materials-Production Properties, Testing and Applications-Narosa Publishing House
3) Robert M. Jones, “Mechanics of Composite Materials”, McGraw Hill Kogakusha Ltd. 1998.
4) Forming Metal Hand Book 9th edition, ASM Hand Book, and v15. 1998, P327-38.
5) Mechanics of composites by Artar Kaw, CEC Press, 2002
6) Composite materials By S.C. Sharma Publishing House, 2000.
7) Composite Science and Engineering By K. K. Chawala Springer Verlag 1998.
8) Introduction to composite materials by Hull and Clyne, Cambridge University Press, 2nd edition, 1990.
9) Composite Materials: Engineering and Science – F. L. Mathew and R. D. Rawlings, Woodhead Publishing Limited

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

1. Define the composites, matrix and reinforcement, the types, benefits and properties of composites.
2. Explain polymer matix composites, their production methods, applications
3. Define and explain metal matix composites, their production methods, applications
4. Understand the mechanics of composite materials, solve the numerical on modulus of rigidity, cutting and joining of composite materials

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
1	1	2	2	1	2	1	2	2	3	2	1	---
2	2	2	1	1	1	1	2	1	2	1	2	2
3	2	1	2	1	1	3	--	1	2	2	1	1
4	2	2	2	3	1	1	2	--	2	1	1	--

UME 727 E	CONTROL ENGINEERING	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

Introduction: Concept of automatic controls, open and closed loop systems, concepts of feedback, requirement of an ideal control system. Types of controllers – Proportional, Integral, Proportional Integral, Proportional Integral Differential controllers.
Mathematical Models: Transfer function models, Models of Mechanical systems, Hydraulic systems.

UNIT – II	10 Hrs

Block Diagrams And Signal Flow Graphs: Transfer Functions definition, function, blocks representation of system elements, reduction of block diagrams, signal flow graphs: Mason's gain formula.
Transient And Steady State Response Analysis: Introduction, first order and second order system response to step, ramp and impulse inputs, concepts of time constant and its importance in speed of response. System stability: Routh's –Hurwitz Criterion.

UNIT - III	10 Hrs

Frequency Response Analysis: Polar plots: Stability Analysis, Relative stability concepts, phase and gain margin, Bode Plots: stability analysis using Bode plots, Simplified Bode Diagrams.

UNIT IV	10 Hrs

Root Locus Plots: Definition of root loci, general rules for constructing root loci, Analysis using root locus
Control Action And System Compensation: Series and feedback compensation, Physical devices for system compensation.

Reference Books:

1. Control systems Engineering U.A. Bakshi and V.U.Bakshi Technical Publications Pune 3rd edition 2011
2. Control Systems Joseph Distefano and Allen Stubberud Schaum's Outline Series 3rd edition 2017
3. Modern Control Engineering Katsuhiko Ogata University of Minnesota. Prentice Hall, New Jersey 5thedition, 2010
4. Control systems Engineering I.J. Nagrath and M. Gopal New Age International Publisher 6thedition, 2018

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

1. Study the fundamental concepts of Control systems and mathematical modeling of the system.
2. To study the concepts of block diagrams & signal flow graph and the basic concepts of proportional, integral, and derivative (PID) control.
3. To study the characteristics of closed-loop control systems, including steady-state and transient response, parametric sensitivity, disturbances, error, and stability.
4. To learn the basics of stability analysis of the system

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
1	3	2	1	2	1	2	2	--	2	2	2	2
2	2	3	2	2	1	2	2	--	2	2	2	2
3	3	2	3	3	2	1	2	--	2	1	1	2
4	3	2	2	2	2	1	2	--	1	2	2	1

UME 728 E	TOOL DESIGN	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

Tool Design Methods: Introduction, the design procedure, drafting, and design techniques in tooling drawing.

Design of Cutting Tools: Introduction, the metal cutting process, revision of metal cutting tools-single point cutting tools, milling cutters, drills and drilling, reamers, taps, selection of carbide tools, determining the insert thickness for carbide tools.

UNIT – II	10 Hrs

Locating and Clamping Methods: Introduction, basic principle of location, locating methods and devices, basic principle of clamping.

Design of Drill Jigs: Introduction, types of drill jigs, general considerations in the design of drill jigs, drill bushings, methods of construction.

UNIT - III	10 Hrs

Design of Fixtures: Introduction, types of fixtures, fixtures and economic.

Design of Press-working Tools: Power presses, cutting operations, types of die – cutting operations and their design, evolution of blanking and progressive blanking.

UNIT IV	10 Hrs

Design of Sheet Metal Bending, Forming and Drawing Dies: Introduction, bending dies, forming dies, drawing dies, evolution of a draw die, progressive dies and selection of progressive dies. Strip development for progressive dies, evolution of progressive dies, examples of progressive dies. Extrusion dies, drop forging dies and auxiliary tools, problems.

Plastics as Tooling Materials: Introduction, plastics commonly used as tooling materials, application of epoxy plastic tools, construction methods, metal forming operations with Urethane dies, calculating forces for Urethane pressure pads, problems.

Reference Books:

1. Cyril Donaldson, G H Lecain and V C Gold. Tool Design, 3rd edition, TMH Publishing Co. Ltd. New Delhi, 2000
2. ASTME, Fundamentals of Tool Design, PHI (P) Ltd. New Delhi, 1983
3. Machine Tool Design and Numerical Control N. K. Mehta Tata McGraw Hill Publisher (P) Ltd, New Delhi 2006
4. Fundamentals of tool design Wilson F. W. ASME PHI, New Delhi 1984

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

1. ***Elucidate*** the design procedure and design of cutting tools.
2. ***Analyze*** the locating and clamping methods and design of jigs
3. ***Design*** of fixtures, press working tools, press tool operations and their economy
4. ***Design*** of sheet metal bending, forming and drawing dies and ***Analyze*** the commonly used polymer tooling materials and design aspects like pressure and forces etc.,

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
1	1	2	3	1	3	--	--	--	--	--	--	1
2	1	2	3	1	1	--	--	--	--	--	--	1
3	2	2	2	1	3	--	--	--	--	--	--	2
4	1	1	2	2	2	--	--	--	--	--	--	2

UME 720 E	POWER PLANT ENGINEERING	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

Introduction: Energy and power, Sources of power, Need power generation, Power plant cycles and classification of power plant cycles, Layout of modern steam power plant, Essential requirements of steam power station, Selection of site for steam power station, Capacity of steam power plant, Choice of steam conditions.

Steam Power Plant: Different types of fuels used for steam generation, Coal handling, Requirements of good coal handling plant, Coal handling systems, Equipment for burning coal in lump form, Strokers, Different types of stokers, Advantages and disadvantages of using pulverized fuel, Equipment for preparation and burning of pulverized coal, Unit system and bin system, Coal burners, Fluidized bed combustion.

UNIT – II	10 Hrs

Ash and dust handling: Ash handling equipment and ash handling systems, Dust collection, Removal of smoke and dust, Dust collectors, Efficiency of dust collectors, Uses of ash and dust, General layout of ash and dust collection systems, Fly ash, Fly ash composition, disposal and application.

Chimney draught: Classification, Natural draught, Chimney height and diameter, Condition for maximum discharge through chimney, Efficiency of chimney, Draught losses, Artificial draught, Forced, Induced and Balanced draught, Advantages of mechanical draught, Numerical problems on chimney draught

UNIT - III	10 Hrs

Boilers: Classification and comparison, Selection of a boiler, Essentials of good boiler, Generation of steam using forced circulation, High and supercritical pressures, L Mont, Benson, Velox, Schmidt, Loeffler and Ramson steam generators.

Accessories: Accessories for the Steam Generator such as super-heaters, Desuperheater, Control of super heaters, Economisers, Air Pre-heaters and re-heaters, Feed water heaters and evaporators

Performance of boilers: Evaporative capacity, Equivalent evaporation, Factor of evaporation, Boiler efficiency, Heat losses in a boiler plant, Numerical problems on boiler performance.

UNIT IV	10 Hrs

Steam turbines: Steam nozzles, Nozzle efficiency, Compounding of steam turbines, Difference between impulse and reaction steam turbines, Turbine efficiencies. Steam condensers; Classification, Comparison between jet and surface condensers, Numerical problems on steam turbines.

Cooling ponds and Cooling towers: Introduction, Natural and artificial ponds, Cooling ponds, Spray ponds. Cooling towers: Introduction, Natural and forced draft cooling towers, Comparison between natural and forced draft cooling towers. Feed water treatment: Impurities in water and troubles caused by the impurities, Methods of feed water treatment, pH value of water.

Cogeneration power plants: Classification, Topping and bottoming cycles, Advantages and disadvantages of steam power plants.

Reference Books:

1. Power Plant Engineering, P.K Nag, 3rd Ed. Tata McGraw Hill2nd ed 2001,
2. Power Plant Engineering, R.K.Rajput, 4 th Ed. Laxmi Publications, 2008,
3. Power Plant Technology, M.M. EL-Wakil, McGraw Hill, International. 1994
4. Power Plant Engineering, Domakundawar, Dhanpath Rai sons.2003

Course Outcomes: At the end of the course student will be able to
1. *Apply* the knowledge of power plant engineering in selecting the types of fuels and burning methods to produce steam. 2. *Apply* the knowledge of power plant engineering in selecting ash, dust handling and chimney draught for a steam power plant. 3. *Apply* the knowledge of power plant engineering to *analyze* boilers, boiler accessories and performance of boilers. 4. *Apply* the knowledge of power plant engineering to *analyze* steam turbines, cooling ponds, cooling towers and co-generation power plants.

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	**Programme Outcomes (POs)**											
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
1	3	2	1	1	1	2	1	3	3	1	1	2
2	3	2	1	1	1	2	1	3	3	1	1	2
3	3	2	1	1	1	2	1	3	3	1	1	2
4	3	2	1	1	1	2	1	3	3	1	1	2

UME 729 E	REFRIGERATION AND AIR CONDITIONING	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

BRIEF REVIEW OF VARIOUS METHODS OF REFRIGERATION: Vapour compression cycle: Analysis of Vapour Compression cycle using P-H and T-S diagrams- calculations, standard rating of operating conditions, Actual vapour compression cycle, Second law analysis of Vapour Compression Cycle.

REFRIGERANTS:
Types of Refrigerants, Comparative study of Ethane and Methane derivatives, of Refrigerants, Requirements of Refrigerants, Effects of lubricants in Refrigerants, substitutes of CFC Refrigerants, Mixture Refrigerants-azeotropic mixtures.

UNIT – II	10Hrs

MULTI PRESSURE VAPOUR COMPRESSION SYSTEMS: Multi stage compression, Multi evaporator systems, Cascade systems, calculation, production of solid carbon dioxide, System practices for multistage system.

EQUIPMENTS USED IN VAPOUR COMPRESSION REFRIGERATION SYSTEM: Compressors, Principle, types of compressors, capacity control. Condensers: Types and construction, Expansion devices: Types- Automatic expansion valve, Thermostatic expansion valves, capillary tube. Sizing Evaporator: Types & construction.

UNIT - III	10 Hrs

Diesel fuels: Properties and rating of fuels; cetane number, chemical energy of fuels, reaction equation, properties of A/F mixture, combustion temp, combustion charts. Vapor pressure, cloud and pour point, annealing point, diesel index, carbon residue.

Combustion in CI engines: Stages of combustion, air fuel ratio in CI engines, delay period, variables affecting delay period, diesel knock, methods of controlling diesel knock, CI combustion chambers, open and divided. Induction swirl, turbulent combustion chambers, types, M - combustion chamber.

UNIT IV	10 Hrs

LOAD CALCULATIONS AND APPLIED PSYCHOMETRICS: Internal heat gains, system heat gains, break up of ventilation load and effective sensible heat factor, Bypass factor, cooling load estimate. Psychometric calculations for cooling. Selection of Air conditioning apparatus for cooling and dehumidification, evaporative cooling.

TRANSMISSION AND DISTRIBUTION OF AIR:
Room Air Distribution, Friction loss in ducts, dynamic losses in ducts, Air flow through simple Duct system, Duct design.

CONTROLS IN REFRIGERATION AND AIR CONDITIONING EQUIPMENTS:
High pressure and low pressure cut out, thermostats, pilot operated solenoid valve, motor controls, bypass control-Damper motor. VAV controls.

Reference Books:

1. Principles of Refrigeration' Dossat, Pearson-2006.
2. 'Heating, Ventilation and Air Conditioning' by McQuistion, Wiley Students edition, 5th edition 2000.
3. 'Air conditioning' by PITA, 4th edition, pearson-2005
4. 'Refrigeration and Air-Conditioning' by Manohar Prasad
5. Refrigeration and Air-Conditioning' by C. P. Arora, Tata McGraw Hill Publication, 2nd edition, 2001.

6. Refrigeration and Air-Conditioning' by W. F. Stoecker, Tata McGraw Hill Publication, 2nd edition, 1982.

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

1. Students will demonstrate the ability to understand vapor compression refrigeration and types of refrigerants.
2. Students will demonstrate the ability to understand multistage vapor compression refrigeration system and equipment used in vapor compression refrigeration system.
3. Student will demonstrate the ability to understand vapor absorption system and psychrometric of air conditioning
4. Students will demonstrate the ability to understand load calculations and applied psychrometric chart transmission and distribution of air, controls in refrigeration and air conditioning equipment's

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	**Programme Outcomes (POs)**											
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
1	1	2	1	1	3	1	2	2	3	1	1	1
2	3	2	3		1	2		1	3	2	3	2
3	1	1	2	1	1	3		1	2	2	3	1
4	3	2	3	2	3	1	2		3	1	2	1

UME 730 E	Operation Management	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

Introduction: Functional subsystems of organization, System concept of production, Types of production system, Productivity, strategic management, World class manufacturing.

Product Design and Analysis: New product development concepts, Process planning and design, Value analysis/Value engineering, Make or buy decision, Ergonomic consideration in product design

UNIT – II	10 Hrs

Forecasting: Nature and use of forecasting, Sources of data, Demand patterns, Factors affecting forecast, types of forecasting, Forecasting Models – Linear Regression, Simple moving average, weighted moving average, e, Single exponential smoothing, Double exponential smoothing, Adjusted exponential smoothing and Delphi method.

Facility Location: Introduction, factors influencing plant location, break even analysis, single facility location problem, Minimax location problem and gravity location problem.

UNIT - III	10 Hrs

Plant Layout and Materials Handling: Introduction, Classification of layout, Layout design procedures – Computerized Relative Allocation of Facilities Technique (CRAFT), Automated Layout Design Program (ALDEP) and, Computerized Relationship Layout Planning (CORELAP).

Line Balancing: Concept of mass production system, objective of assembly line balancing, rank positional weight method and the COMSOL Algorithm.

UNIT IV	10 Hrs

Modern Production Management Tools: Just-In-Time manufacturing – introduction and overvies of JIT, basic principles, push/pull production, kanban systems (pull systems). Total Quality Management – scope of TQM, benefits of TQM, quality control activities during product cycle, operating quality costs. Kaizen – Key elements of kaizen, classification of kaizen, steps of implementation of kaizen Blitz, guidelines of kaizen team, benefits of kaizen. Lean Manufacturing – steps of lean manufacturing, components of lean manufacturing.

Reference Books:

1. Modern Production/Operations Management, Buffa, Wiley Eastern Ltd.2001
2. Operations Management, Joseph G MonksMc Graw Hill 1987.
3. Production and Operations Management, R. Panneerselvam. Prentice Hall of India Pvt Ltd. 2005.
4. Analysis and Control of Production Systems, 2nd Edition, Elsayed A. Elsayed, Thomas O. Boucher, Pearson, 1994
5. Production and Operations Management, R. B. Khanna, PHI, 2010.

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

1. Students will demonstrate the ability to understand vapor compression refrigeration and types of refrigerants.
2. Students will demonstrate the ability to understand multistage vapor compression refrigeration system and equipment used in vapor compression refrigeration system.
3. Student will demonstrate the ability to understand vapor absorption system and psychrometric of air conditioning
4. Students will demonstrate the ability to understand load calculations and applied psychrometric chart transmission and distribution of air, controls in refrigeration and air conditioning equipment's

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
1	1	2	1	1	3	1	2	2	3	1	1	1
2	3	2	3	--	1	2	--	1	3	2	3	2
3	1	1	2	1	1	3	--	1	2	2	3	1
4	3	2	3	2	3	1	2	--	3	1	2	1

UME 705 L	CAE LABORATORY	01 - Credits (0 : 0 : 2)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I

1. Study of a FEA package and stress analysis of
2. Trusses – (Minimum 2 exercises).
3. Beams – Simply supported, cantilever beams with UDL and with varying load.

UNIT – II

1. Stress analysis of a rectangular plate with a circular hole.
2. Thermal Analysis – 2D problem with conduction and convection boundary conditions.
3. Fluid flow Analysis – Potential distribution in the 2D bodies.
4. Dynamic Analysis
   1) Fixed – fixed beam for natural frequency determination.
   2) Bar subjected to forcing function.
   3) Fixed – fixed beam subjected to forcing function.

REFERENCE BOOKS:

1. A first course in the Finite element method by Daryl L Logan, Thomason, Third Edition.
2. Fundaments of FEM by Hutton – McGraw Hill, 2004.
3. Finite Element Analysis by George R. Buchanan, Schaum Series.

Scheme for Examination:

1. Each laboratory subject is evaluated for 100 marks (50 CIE and 50 SEE).
2. The CIE in laboratory in classes is carried out for 50 marks (30 marks for the performance and term work).
3. For remaining 20 marks one practical test to be conducted.

The SEE practical is conducted for 50 marks two question to be set from each Part A, and Part B. for 20 marks each and 10 marks Viva voce.

1. To demonstrate the ability to create models for trusses, frames, plate structures, machine parts, and components using ANSYS general-Purpose software;
2. To model multi-dimensional heat transfer, flow analysis, model problems and harmonic problems using ANSYS;
3. To demonstrate the ability to evaluate and interpret FEA analysis results for design and evaluation purpose;
4. To develop a basic understanding of the limitations of the FE method and understand the possible error sources in its use.

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
1	3	1	1	2	1	3	3	3	3	3	1	3
2	3	2	2	1	2	2	1	1	2	2	3	3
3	2	1	2	1	1	2	1	2	2	2	1	2
4	1	2	3	2	2	2	2	2	3	2	2	2

UME 706L	CNC LABORATORY	01 - Credits (0 : 0 : 2)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

Part-A

1. Programming on lathe for facing
2. Programming on lathe for simple turning
3. Programming on lathe for step turning
4. Programming on lathe for groove cutting

Part-B

5. Programming on milling with drill tap attachment for facing
6. Programming on milling with drill tap attachment for drilling
7. Programming on milling with drill tap attachment for tool path movement

Scheme for Examination:

1. Each laboratory subject is evaluated for 100 marks (50 CIE and 50 SEE).
2. The CIE in laboratory in classes is carried out for 50 marks (30 marks for the performance and term work).
3. For remaining 20 marks one practical test to be conducted.

The SEE practical is conducted for 50 marks two question to be set from each Part A, and Part B. for 20 marks each and 10 marks Viva voce.

1. Understand the basic procedures and concepts of programming, set up and operation of a CNC Machining Center.
2. Identify and understand the basic programming codes.
3. Create geometry and tool paths from the specifications for simple parts
4. Identify and define the functions of the CNC machine control.
5. Set up the CNC machining center for manufacturing simple parts
6. Manufacture simple parts on the CNC machining center.

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
1	2	3	3	3	3	1	2	1	3	2	2	3
2	3	3	3	3	3	1	1	2	3	3	3	3
3	2	2	2	2	1	1	2	1	3	1	2	1
4	3	3	3	2	3	3	1	3	3	2	3	2

UME 833 E	ADVANCED METAL JOINING PROCESSES	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs
Distortion, methods to avoid distortion. Stresses in Joint Design, Welding and Cladding of dissimilar materials, concepts and metallurgical problems in dissimilar metal welding / joining. Electro Slag, Welding Electron Beam Welding, Plasma arc Welding, Laser Beam Welding, Explosion Welding, Di Welding, Ultrasonic Welding, Friction welding and Thermit welding,	
UNIT – II	**10 Hrs**
Advanced brazing processes, different types: conventional brazing, active metal brazing, furnace brazing. Advantages, disadvantages. Welding of plastics: principle, common weld able plastics, heated tool welding, hot gas welding, high frequency welding, and ultrasonic welding. Inspection of Welds: Destructive techniques like Tensile, Bend, Nick break, Impact & Hardness. Non-Destructive techniques like 'X' rays, Ultrasonic, Magnetic particle, Dye Penetrant, Gamma ray inspection.	
UNIT - III	**10 Hrs**
Welding Symbols-Need for, Representing the welds, Basic weld symbols, Location of Weld, Supplementary symbols, Dimensions of welds, Examples Welding Introduction, Principles of sound welding design, Welding joint design. Welding positions, Allowable strengths of welds, under steady loads.	
UNIT IV	**10 Hrs**
Quality Control in Welding - Introduction, Quality assurance v/s Quality control, Weld quality, Discontinuities in welds, their causes and remedies and Quality conflicts. Computer-Aided Welding Design: Introduction. Principles of sound welding design, Wilding joint design. Welding positions. Allowable strengths: of welds .under steady loads. Weld throat thickness.	
Reference Books: 1. Welding Engineering Hadbook by A.W.S. 2. Welding Engineering by Rossi. 3. Advanced Welding processes - Nikodaco&Shansky MIR Publications. . 4. Welding Technology by O.P. Khanna. 5. Welding for engines byUdin, funk & Wulf **6.** Welding and welding technology- R.L Little.	

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
1	1	1	1	1	1	1	1	1	1	1	2	1
2	2	1	1	2	1	2	2	1	3	2	2	1
3	1	3	1	1	1	1	2	1	1	1	1	1
4	3	3	1	2	1	2	1	1	3	2	2	1

UME 834 E	Product Design and Rapid Prototyping	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs
Introduction : Definition , importance of PD, Objectives of PD,essential requirements of PD, who designs product, Project team, steps in new PD, Characteristics of successful product development, duration and cost of product development , challenges of product development, Design for manufacture, re-manufacturing , sequential and concurrent engineering . **Design for manufacture & assembly:** Design for Manufacture and Assembly, History , Implementation of Design for Assembly , Design for Manufacture , How Does DFMA Work, Advantages of Applying DFMA during Product Design design for Maintainability, Design for Environment Design for safety, Vision and Illumination design	
UNIT – II	**10 Hrs**
Development processes and organizations: A generic development process, Usefulness of a well-defined Development Process, task & responsibilities for marketing, design and manufacturing , concept development: the front end process, adopting the generic product development process, process flow diagram for variant of products, product development organizations (functional, project & matrix)	
UNIT - III	**10 Hrs**
Introduction to RP **Prototype fundamentals**,definition of Prototypes, types of prototypes, need for the compression in product development, RP fundamentals , RP wheel, history of RP systems, applications of RP, growth of RP industry, basic principle of rapid prototyping processes, classification of RP systems . advantages and disadvantages of rapid prototyping. **Stereolithogrphy systems:** principle, process details , advantages and disadvantages, applications	
UNIT IV	**10 Hrs**
Selective Laser sintering: principle, process details , advantages and disadvantages, applications **Fused deposition modeling**: principle, , process details , advantages and disadvantages, applications **Laminated object manufacturing :** principle, process details, LOM materials advantages and disadvantages, applications **Solid Ground curing:** principle of operation , machine details, advantages and disadvantages, applications	
Reference Books: 1. The design of everyday things by Don Norman 2. Product designs from concept to Manufacture by Jennifer Hudson 3. Additive manufacturing by Brent Stucker, David W. Rosen, and lan Gibson 4. Engineering design and rapid prototyping by Ali K. Kamrani and Emad Abouel Nasr 5. Product design & development by Karl T Ulrich and Steven D Eppinger 6. Rapid Prototyping principles and applications by C K Chua, K F Leong and C S Lim	
Course Outcomes: By the end of course with aid of design data handbook students shall be able to, 1. Express basics of product design as a means to manage the development of an idea from concept to production 2. Analyze evaluate and apply the generic method for product development 3. Evaluate basics of prototyping 4. Demonstrate Stereolithogrphy , selective laser sintering , fused deposition modeling , laminated object manufacturing & solid ground curing	

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
1	1	1	1	1	1	1	1	1	1	1	2	1
2	2	1	1	2	1	2	2	1	3	2	2	1
3	1	3	1	1	1	1	2	1	1	1	1	1
4	3	3	1	2	1	2	1	1	3	2	2	1

UME 828 E	INFORMATION TECHNOLOGY APPROACH IN MANUFACTURING	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

Information Technology and the Increasing Complexity of Manufacturing: Introduction, Information Technology for Manufacturing- Definition and Elements, Flexibility for the future, Recognizing Information Technology's Increasing Capability in a Changing World, New Manufacturing Styles.

IT Systems: Computer Hardware- Fundamentals, Classification of Computers, Design Workstations, Principles of Networking, Private Computer Communication Networks, (VPN, PSDN,ISDN), Network Topologies, Transmission Media, Intranet, Internet.

UNIT – II	10 Hrs

Introduction to CIM Database: Database requirements of Manufacturing, Database, Features of Database Management System, Database Models-Hierarchical, Network and Relational, DBMS architecture, Query Language. SQL as a knowledge base query language.

Product Data Exchange: Introduction, Types of Translators, IGES, STEP, ACIS and DXF, Processors, Case Study on STEP.

UNIT - III	10 Hrs

Concurrent Engineering: Introduction, Implementation of concurrent engineering, Concurrent engineering and Information Technology, Soft and Hard prototyping, Characteristics of Concurrent Engineering, Key factors influencing the success of CE, Examples of CE.

Collaborative Design: Introduction, Distributed Computing, Intranets and Extranets, Instant Messaging, Virtual Reality Modeling Language, Traditional Design, Collaborative Design, Collaborative Principles,Collaborative approaches, Collaboration Tools, Collaborative Design Systems.

UNIT IV	10 Hrs

Planning of Resources for Manufacturing through Information Systems: Introduction, Role of MRP-II in a CIM system, Manufacturing Applications, Engineering Applications, Dynamic Enterprises, ERP, SCM, Selection of an ERP package, ERP in India, Dynamic Enterprise Modelling (DEM).

IoT: IoT Overview, IoT Hardware, Iot Software, IoT Technology and Protocols, IoT Common Uses, IoT Manufacturing Applications, Energy applications.

Reference Books:

1. Radhakrishnan, Subramanyan, V. Raju, "CAD/CAM/CIM", NewAge International Publishers, Third Edition.
2. Mikell P. Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing", Prentice-Hall of India Pvt. Ltd. Second Edition.
3. Ibrahim Zeid, "Mastering CAD/CAM", Tata McGraw-Hill Publishing Company Ltd.
4. Internet of Things, www.tutorialpoint.com
5. https://www.nap.edu/read/4815/chapter/1

Course Outcomes: By the end of course with aid of design data handbook students shall be able to,

1. Understand and identify the manufacturing sector with the application of Information Technology theory and tools. Learn the IT system ingredients to understand concepts, specifications, and

applications.

2. Understand the method of transforming the design and manufacturing information into data, identify the classification and application of different data management methods.
   gain knowledge of Query language and knowledge of handling manufacturing data using different types of file systems.
3. Study the role of Information Technology in manufacturing sequences comprising of various production activities. Apply the concepts of concurrent engineering, collaborative design in manufacturing network.
4. Apply the concept of the ERP in manufacturing; understand the concept of IoT and its applications.

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)		Programme Outcomes (POs)											
		PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
3.	1	4. -	5.	6.	7.	8.	9.	10. -	11. -	12. -	13. -	14. -	15. -
16.	2	17.	18.	19.	20.	21.	22.	23. -	24.	25. -	26.	27. -	28.
29.	3	30. -	31.	32.	33.	34. -	35.	36.	37.	38. -	39. -	40.	41. -
42.	4	43. -	44.	45.	46. -	47.	48.	49. -	50. -	51.	52.	53.	54. -

UME 835 E	THEORY OF ELASTICITY	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs
DEFINITIONAND NOTATION: Stress, Stress at a Point, Equilibrium Equations, Principal Stresses, Mohr's Diagram, Maximum Shear Stress, Boundary Conditions. **STRAIN AT A POINT:** Compatibility Equations, Principal Strains, Generalized Hooke's law, Methods of Solution of Elasticity Problems – Plane Stress-Plane Strain Problems.	
UNIT – II	**10 Hrs**
TWO DIMENSIONAL PROBLEMS: Cartesian co-ordinates – Airy's stress functions – Investigation of Airy's Stress function for simple beam problems – Bending of a narrow cantilever beam of rectangular cross section under edge load – method of Fourier analysis – pin ended beam under uniform pressure. **GENERAL EQUATIONS IN CYLINDRICAL CO-ORDINATE:** Thick cylinder under uniform internal and / or external pressure, shrink and force fit, stress	
UNIT - III	**10 Hrs**
STRESSES IN AN INFINITE PLATE: Stress in infinite plate with a circular hole subjected to uniaxial and biaxial loads, stress concentration, stresses in rotating discs and cylinders. **TORSION OF CIRCULAR, ELLIPTICAL AND TRIANGULAR BARS:** Torsion of circular, elliptical and triangular bars, membrane analogy, torsion of thin open sections and thin tubes.	
UNIT IV	**10 Hrs**
THERMAL STRESSES: Thermo elastic stress strain relationship, Equations of equilibrium Thermal stresses in thin circular discs. **UNIQUENESS THEOREM:** Principle of super position, reciprocal theorem, Saint Venant principle.	

Reference Books:

1. Applied Elasticity-C.T. Wang-Tata Mc. Graw Hill-1953
2. Theory of Elasticity -Sadhu Singh-Khanna Publishers-1997.
3. Elasticity in Engineering Mechanics, , -A. P. Boresi and K. P. Chong- John Wiley &Sons-2nd Edition, 2000.
4. Advanced Strength and Applied Elasticity.-A. C. Ugural and S. K. Fenster-Elsevier-2nd Edition, 1987.
5. Theory of elasticity -T.G.Sitaram-Springer-2021
6. Advanced Mechanics of solids -L. S. Srinath-Tata Mc. Graw Hill-2003
7. Theory of Elasticity-S. P. Timoshenko and J. N Goodier-Tata Mc. Graw Hill-2006
8. Elasticity: Theory, Applications and Numeric's-Martin H. Sadd,-Academic Press, -2010

Course Outcomes: By the end of course with aid of design data handbook students shall be able to,

1. Understand the basic concepts in continuum mechanics of solids, including of strain, internal force, stress and equilibrium in solids
2. Understand and solve the basic problems of the theory of elasticity by using Airy function expressed as biharmonic function. And in polar coordinate system.
3. Understand and solve torsion problems in bars and thin walled members.
4. Understand index notation of equations, tensor and matrix notation applied to thermal stresses.

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	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
1	3	2	2	2	2	1	1	2	1	1	1	3
2	3	2	3	2	2	2	1	1	1	1	1	2
3	2	3	2	2	2	1	2	2	1	1	1	1
4	2	2	3	2	2	1	2	1	1	1	1	2

UME 821 E	DESIGN OF MECHANISMS	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

Geometry of motion: Introduction, analysis and synthesis, mechanism terminology, planar, spherical and spatial mechanisms, mechanical advantage, equivalent mechanisms, unique mechanisms.

Generalized principles of dynamics: Fundamental laws of motion, generalized coordinates, configuration space, constraints, virtual work, principle of virtual work, energy and momentum, work and kinetic energy, equilibrium and stability, kinetic energy of a system, angular momentum

UNIT – II	10 Hrs

Lagrange's Equation: Larange's equation from D.Alembert's principles, examples, Hamiltons equations, Hamiltons principle, Lagrange's equation from Hamiltons principle, derivation of Hamiltons equations, examples.

Synthesis of linkages: Type, number, and dimensional synthesis, function generation, path generation and body guidance, Precision positions, structural error, Chebychev spacing, two position synthesis of slider crank mechanisms, crank-rocker mechanisms with optimum transmission angle.

UNIT - III	10 Hrs

Motion generation: Poles and relative poles, relative poles of 4-bar mechanism, relative poles of slider crank mechanism.

Graphical methods of dimensional synthesis: Two position synthesis of crank and rocker mechanisms, three position synthesis, four position synthesis (point precision reduction), overlay method, coupler curve synthesis, cognate linkages.

UNIT IV	10 Hrs

Analytical methods of dimensional synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, examples, Bloch's method of synthesis.

Cams: Introduction, pressure angle, parameters affecting pressure angle, effect of offset follower motion, radius of curvature and undercutting, cams with specified contours.

Reference Books:

1. 'Mechanism & machine Theory', A.G. Ambekar, PHI, 2007
2. 'Kinematics, Dynamics & Design of Machinery', K. J. Waldron, G. L. Kinzel, Wiley India, 2007.
3. 'Design of Machinery', R. C. Nortan , Tata McGraw Hill
4. "Theory of Machines and Mechanism", E. Shigley, J. J. Uicker, McGraw Hill Company.
5. "Classical Dynamics", Greenwood, Prentice Hall of India, 2004

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

1. Analyze and design mechanisms to create arbitrary motion.
2. Know the position synthesis of planar mechanism.
3. Design the planar mechanisms both analytical and by graphical solutions.
4. Design and construct a working mechanism in small teams and to document the design in a detailed report

Table: Matrix to describe the mapping of POs with Cos

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1	3	2	2	2	2	1	1	2	1	1	1	3
2	3	2	3	2	2	2	1	1	1	1	1	2
3	2	3	2	2	2	1	2	2	1	1	1	1
4	2	2	3	2	2	1	2	1	1	1	1	2

UME 811 C	HYDRAULICS AND PNEUMATICS	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

Introduction to Hydraulic Power: Pascal's law, The Source of Hydraulic Power: Pumps Pumping theory, pump classification, gear pumps, vane pumps, piston pumps, pump performance, variable displacement pumps.

Hydraulic Actuators and Motors: Linear Hydraulic Actuators [cylinders], Mechanics of Hydraulic Cylinder load Rotary Actuators, Gear motors, vane motors and piston motors.

UNIT – II	10 Hrs

Control Components in Hydraulic Systems: Directional Control Valves – Symbolic representation, Constructional features, pressure control valves – direct and pilot operated types, flow control valves.

Maintenance of Hydraulic systems: Hydraulic oils – Desirable properties, general type of fluids, sealing devices, system, filters and strainers, problem caused by gases in hydraulic fluids, wear of moving parts due to solid particle temperature control, trouble shooting.

UNIT - III	10 Hrs

Hydraulic Circuit Design and Analysis: Control of single and Double – acting Hydraulic cylinder, regenerative circuit, pump unloading circuit, Double pump Hydraulic system, Counter Balance Valve application, Hydraulic cylinder sequencing circuits. Locked cylinder using pilot check valve, cylinder synchronizing circuits, speed control of hydraulic cylinder, speed control of hydraulic motors, accumulators and accumulator circuits.

UNIT IV	10 Hrs

Neumatic Controls: Choice of working medium, characteristics of compressed air,.preparation of compressed air- Driers, Filters, Regulators, Lubricators, Distribution of compressed air- Piping layout. Pneumatic Actuators: Linear cylinders – Types, conventional type of cylinder working, end position cushioning, seals. Rod – less cylinders – types, working advantages. Rotary cylinder types construction.

Directional Control valves: Design and constructional aspects, poppet valves, slide valves spool valve, suspended seat type slide valve.

Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders. Flow control valves and speed cor supply air throttling and exhaust air throttling use of quick exhaust valve.

Reference Books:

1. Oil Hydraulic Systems - Principles and Maintenance, S.R. Majumdar, Tata Mc Graw Hill publish company Ltd. 2001.
2. Pneumatic Systems, S.R. Majumdar, Tata Mc Graw Hill publishing Co., 1995.
3. Industrial Hydraulics, Pippenger, Hicks, McGraw Hill, New York.
1. Fluid Power with applications, Anthony Esposito, Fifth edition pearson education, Inc. 2000.
4. Pneumatics and Hydraulics, Andrew Parr. Jaico Publishing Co.2000.

Course Outcomes: By the end of course with aid of design data handbook students shall be able to,

1. Understand the basics of Hydraulics and pneumatics

2. Describe various components of hydraulic system and maintenance of hydraulic system for various applications
3. Design hydraulic and pneumatic system for various applications

Question paper pattern for SEE:

1. Total of eight questions with two from each unit to be set uniformly covering the entire syllabus.
2. Each question carries 20 Marks and should not have more than 4 subdivisions
3. Any five full questions are to be answered choosing at least one from each unit.

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1	1	2		2								1
2	2	1	1	1		2	2	3	1	3	2	1
3	1	2	1	1		2	1	2	2	3	1	

UME 830 E	NON-CONVENTIONAL ENERGY	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

Introduction: Energy sources, need for non-conventional energy sources, energy alternatives, advantages and disadvantages.

Solar Radiation: Extra-Terrestrial radiation, solar constant, beam, diffuse and global radiation, Measurement of Solar Radiation: Pyranometer, shading ring pyrheliometer, sunshine recorder, principle of working.

UNIT – II	10 Hrs

Solar Radiation Geometry: Solar time, latitude, declination angle, altitude, surface azimuth angle, hour angle, zenith angle, angle of incidence, day length, problems on day length.

Solar Thermal Conversion: Collection and storage, thermal collection devices, liquid flat plate collectors, concentrating collectors (cylindrical, parabolic, paraboloid) power generation.

UNIT - III	10 Hrs

Wind Tidal and Ocean Thermal Energy: Wind power: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis windmills.

Tidal power: Fundamental characteristics of tidal power, harnessing tidal energy, limitations.

Ocean Thermal Energy Conversion: Principle of working, problems associated with OTEC.

UNIT IV	10 Hrs

Biogas Hydrogen Fuel cell and Photovoltaic: Biogas production from waste biomass, Use of biogas in IC engines, advantages of anaerobic digestion, floating drum (constant pressure) type, fixed dome (constant volume) type biogas plants, comparison.

Hydrogen: Hydrogen as energy carrier, storage, conversion, applications and safety.
Fuel cell: Principle of working, Types, Salient features of each fuel cell, applications.
Photovoltaic: Solar photovoltaic systems, advantages, disadvantages and applications.

Reference Books:

1. Non-Conventional Energy System-S K Agarwal-APH Publishing Corporation- 2005
2. Non-conventional Energy Systems-K. M. Mital-A H Wheeler Publishing Co Ltd-1999
3. Non-Conventional Energy Source and Utilization -R K Rajput-S Chand &Company-2014
4. Non-Conventional Energy Resources -B.H. Khan-McGraw Hill Education India Private Limited-3rd edition, 2017
5. Solar energy -Subhas P Sukhatme-Tata McGraw Hill -2nd Edition, 1996
6. Non-Conventional Energy Sources -G.D Rai -Khanna-2nd Edition1988

Course Outcomes: By the end of course with aid of design data handbook students shall be able to,

1. Know the conventional and non-conventional energy sources, measurement of solar radiation.
2. Understand solar radiation geometry and various solar thermal devices
3. Know importance of wind energy, tidal energy and ocean thermal energy conversion system.
4. Know about the production of biogas, advantages, Hydrogen energy and its applications, photovoltaic and fuel cells

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	**Programme Outcomes (POs)**											
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
1	1	2	2	2	2	1	2	2	2	2	1	--
2	2	2	2	1	1	1	2	1	3	1	3	2
3	1	1	2	1	1	3	--	1	2	2	1	1
4	3	2	3	2	1	1	2	--	3	1	2	--

UME 836 E	Computational Fluid Dynamics	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs

Introduction: Introduction to computational fluid dynamics, advantages, limitations and applications.
CFD solution procedure: Preprocessor: Selection of computational domain, selection of flow model, grid generation, fluid properties and flow variables. Solver: Discretization of governing equations, solutions of governing equations. Post processor: various post processing methods.

UNIT – II	10 Hrs

Governing equations: Continuity equation, momentum equation, energy equation, physical boundary conditions, introduction to turbulence and standard k-ε turbulence model.

UNIT - III	10 Hrs

Classification: Classification of partial differential equations, general behavior of different classes of partial differential equations, well posed problems.
CFD Techniques: Discretisation of governing equations, finite difference method, finite volume method, converting governing equations to algebraic equation system, implicit and explicit approaches.

UNIT IV	10 Hrs

CFD solution methods: Central difference and upwind schemes applied to 1-D situation involving convection and diffusion terms, Maccormack's technique applied to unsteady 2-D inviscid flow, pressure velocity coupling (SIMPLE scheme applied to incompressible viscous flow).
Numerical solution of algebraic equations: Direct and iterative methods, Thomas algorithm, Jacobi and Gauss - Siedel methods.
CFD solution analysis: Consistency, stability, convergence, accuracy and efficiency, sources of solution errors, verification and validation.

Reference Books:

1. Computational Fluid Dynamics-A Practical Approach-JiyuanTu, Guan HengYeoh, and Chaoqun Liu,-Butterworth-Heinemann-2008,
2. Fundamentals of Computational Fluid Dynamics-Tapan K. Sengupta,-Universities Press Private Ltd.-**2005**
3. Computational Fluid Dynamics for Engineers-Tuncer Cebeci, Jian P. Shao, FassiKafyeke and Eric Laurendeau,-Horizons Publishing-**2005**
4. "Computational Fluid Dynamics"-John D. Anderson,-McGraw Hill,-2013

Course Outcomes: By the end of course with aid of design data handbook students shall be able to,

1. *Define* the need, advantages , disadvantages and steps involved in CFD
2. *Apply* the governing equations of fluid flow to *compile* the scope and applicability of equations.
3. *Analyze* the governing equations of fluid flow using finite difference/finite volume method.
4. *Analyze* the fluid flow computational solutions and methods to *compile* the CFD solutions.

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
1	1	2	2	1	1	--	--	1	--	3	--	1
2	2	2	2	2	1	--	--	1	--	2	--	1
3	2	1	2	2	2	--	--	--	--	3	--	3
4	2	1	3	3	3	2	--	--	--	--	1	--

UME 829 E	RELIABILITY ENGINEERING AND EXPERIMENTAL DESIGN	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs
BASICS OF RELIABILITY: Reliability: Definition and basic concepts of Reliability; Life-cycle curve and Probability distributions in modeling; Probability distributions to model failure rate; System Reliability: Systems with components in series; Systems with components in parallel; Systems with components in series and parallel; Systems with standby components.	
UNIT – II	**10 Hrs**
RELIABILITY AND LIFE TESTING PLANS: Operating characteristics curves; Types of tests; Failure-terminated test; Time-terminated test; Sequential reliability testing; Life testing plans using the exponential distribution; Standard life testing plans using Handbook H 108.	
UNIT - III	**10 Hrs**
EXPERIMENTAL DESIGN: Introduction; Experimental design fundamentals; Some experimental design; Completely randomized design; Randomized block design; Latin square design; Factorial experiments; Two-factor factorial experiment; Role of contrasts; The 2k factorial experiment.	
UNIT IV	**10 Hrs**
THE TAGUCHI METHOD: The Taguchi philosophy; Loss function; Signal-to-Noise-Ratio and Performance measures; Critique to S/N Ratios; Experimental design in the Taguchi Method; Orthogonal arrays and linear graphs; Estimation of effects; Parameter design in Taguchi method; Critique to experimental design and the Taguchi Method	
Reference Books: 1. Introduction to Reliability Engineering by Dhilan& Singh **2.** Robust design by Sunil Phadike 3. Fundamentals of Quality Control and Improvement by Amitava Mitra, Prentice Hall of India New Delhi **4.** 2. Probability, Statistics and Random Processes by T Veerarajan, Tata McGraw-Hill New Delhi	
Course Outcomes: By the end of course with aid of design data handbook students shall be able to, 1. To have the knowledge about role of reliability engineering in systems design and analysis 2. To understand the concept of life testing plans and apply them to engineering components 3. To apply the Experimental design concepts in design and development of engineering products 4. To know the principles of Taguchi method and apply them to engineering concepts.	

Table: Matrix to describe the mapping of POs with Cos

Course Outcomes (COs)	Programme Outcomes (POs)											
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
1	1	3	2	1	3	--	--	--	--	--	--	--
2	1	1	3	1	1	--	--	--	--	--	1	--
3	2	2	2	1	3	--	--	--	--	--	3	--
4	1	1	2	2	2	--	--	--	--	--	3	--

UME 831 E	SUPPLY CHAIN MANAGEMENT	03 - Credits (3 : 0 : 0)
Hrs./Week : 03		CIE Marks : 50
Total Hours : 40		SEE Marks : 50

UNIT – I	10 Hrs
Framework of Supply Chains: Introduction to supply chain, The objective of a supply chain, The importance of supply chain decisions, Decision phases in a supply chain, Process views of a supply chain: Cycle view of supply chain processes, Push/Pull view of supply chain processes, Examples (minimum two) of Supply Chains.	

Performance of Supply Chains: Competitive and supply chain strategies, Achieving strategic fit: Understanding the customer and supply chain uncertainty, Understanding the supply chain capabilities, Achieving strategic fit, Issues affecting strategic fit, Expanding strategic scope, Drivers of supply chain performance, Framework for structuring drivers, Facilities, Inventory, Transportation, Information, Sourcing, Pricing.

UNIT – II	10 Hrs

Designing the Supply Chain Network: The role of distribution in the supply chain, Factors influencing distribution network design, Design options for a distribution network: Manufacturer storage with direct shipping (MSWDS), MSWDS and in-transit merge, Distributor storage with package carrier delivery, Distributor storage with last-mile delivery, Manufacturer or Distributor storage with customer pick-up, Retail storage with customer pickup, Selecting a distributor network design.

Transportation in a Supply Chain: The role of transportation in a Supply Chain, Modes of transportation, Design options for a transportation network: Direct shipment network, Direct shipping with milk-runs, All shipments via central-DC, Shipping via DC using milk-runs, Tailored network, Tailored transportation: By customer density and distance, By size of customer, The Role of IT in transportation, Risk management in transportation, Making transportation decisions in practice.

UNIT - III	10 Hrs

Demand forecasting in a Supply Chain: The role of forecasting in a supply chain, Characteristics of forecasts, Components of a forecast and forecasting methods, Basic approach to demand forecasting, The role of IT in forecasting, Risk management in forecasting, Forecasting in practice.

Sourcing and Cross-Functional Drivers in a Supply Chain: The role of sourcing in a supply chain, In-house or Outsource, Risks of using a Third-party, Supplier scoring and assessment, The procurement process, Sourcing planning and analysis, The Role of IT in Sourcing, Risk Management in Sourcing, Making Sourcing Decisions in Practice.

UNIT IV	10 Hrs

Information Technology in a Supply Chain: The Role of IT in a supply chain, The supply chain IT framework, Customer Relationship Management (CRM), Internal supply chain management, Supplier Relationship Management (SRM), The Transaction Management Foundation, The future of IT in the supply chain, Risk Management in IT, Supply Chain IT in Practice.

Coordination in a Supply Chain: Lack of Supply Chain Coordination and the Bullwhip Effect, The Effect on performance of lack of coordination, Obstacles to coordination in a supply chain, Managerial levers to achieve coordination, Building strategic partnerships and trust within a supply chain, The Role of IT in Coordination, Achieving Coordination in Practice

Reference Books:

1. Supply Chain Management–Strategy, Planning & Operation. -Sunil Chopra, Peter Meindl & D V Kalra-Pearson Prentice Hall (Education, South Asia)-Third Edition 2007
2. Supply Chain Redesign–Transforming Supply Chains into Integrated Value Systems.-Robert B Handfield, Ernest L Nichols, Jr-Pearson Education/Financial Times Prentice Hall PTR-2002
3. Sustainable Logistics and Supply Chain Management: Principles and practices for sustainable operations and management-David B Grant, Alexander Trautrims and Chee Yew Wong-Kogan Page Limited-Second edition
4. Purchasing and Supply Chain Management: Strategies and Realities-Michael Quayle-IRM Press-2006

Course Outcomes: By the end of course with aid of design data handbook students shall be able to,

1. Demonstrate the supply chain objectives, importance, decision phases, process views, performance with strategic fit and their impact on success of a supply chain.
2. Develop a distribution network with different modes of transportation, understanding the effect of e-business on the design of distribution networks in different industries.
3. Express the role of forecasting and sourcing with their risk management.
4. Analyze technology and coordination in a supply chain, applications of IT for supply chain drivers and the processes that enable supply chain performance.

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Course Outcomes (COs)	Programme Outcomes (POs)											
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
1	--	--	1	--	--	--	--	--	--	--	--	1
2	--	--	--	1	1	--	--	--	--	1	--	1
3	1	--	--	1	1	--	--	--	--	--	--	1
4	--	--	--	--	3	--	--	--	--	--	--	1