SDM COLLEGE OF ENGINEERING AND TECHNOLOGY, DHARWAD
Department of Mechanical Engineering

List of new courses introduced during the last five years

III Semester

Course Code	Course Category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	*Max. Marks	Duration in Hrs.	Max. Marks	Duration In Hrs.
18UMAC300	BS	Engg. Mathematics-III	3 - 0 - 0	3	50	100	3	-	-
18UMEC300	PC	Basic Thermodynamics	3 - 2 - 0	4	50	100	3	-	-
18UMEC301	PC	Materials Science	4 - 0 - 0	4	50	100	3	-	-
18UMEC302	PC	Strength of Materials	3 - 2 - 0	4	50	100	3	-	-
18UMEC303	PC	Manufacturing Processes- I	3 - 0 - 0	3	50	100	3	--	--
18UMEC304	PC	Machine Drawing	2 - 0 - 2	3	50	100	3	--	--
18UMEL305	PC	Materials Science & Material Testing Lab	0 - 0 - 3	**1.5**	50	--	--	50	3
18UMEL306	PC	Foundry & Forging Lab	0 - 0 - 3	**1.5**	50	--	--	50	3
	Total		**18 -4- 8**	**24**	**400**	**600**		**100**	

BS- Basic Science, PC- Program Core

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IV Semester

Course Code	Course Category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	*Max. Marks	Duration in Hrs.	Max. Marks	Duration In Hrs.
18UMAC400	BS	Engg.Mathematics-IV	3 - 0 - 0	3	50	100	3	-	-
18UMEC400	PC	Fluid Mechanics	3 - 2 - 0	4	50	100	3	-	-
18UMEC401	PC	Manufacturing Processes - II	4 - 0 - 0	4	50	100	3	-	-
18UMEC402	PC	Applied Thermodynamics	3 - 2 - 0	4	50	100	3	-	-
18UMEC403	PC	Metrology &Measurements	3 - 0 - 0	3	50	100	3	--	--
18UMEC404	PC	Design of Machine Elements-I	2 - 2 - 0	3	50	100	3	--	--
18UMEL405	PC	Measurements Lab	0 - 0 - 3	**1.5**	50	--	--	50	3
18UMEL406	PC	Thermal Engg. Lab - I	0 - 0 -3	**1.5**	50	--	--	50	3
18UMEL407	PC	Introductory Project	0 - 0 -2	1	50	--	--	--	--
		Total	**18 - 6 -8**	**25**	**450**	**600**		**100**	

BS- Basic Science, PC- Program Core

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V Semester

Course code	Course title	Teaching		Examination				
				CIE	Theory (SEE)		Practical (SEE)	
		L-T-P (Hrs/week)	Credits	Max. Marks	*Max Marks	Duration in hours	Max. Marks	Duration in hours
15UMEC500	Management, Economics & Intellectual Property Rights.	4-0-0	4	50	100	3		
15UMEC501	Kinematics of Machines	3-2-0	4	50	100	3	-	-
15UMEC502	Turbo machines	3-2-0	4	50	100	3	-	-
15UMEC503	Machine Design – II	3-2-0	4	50	100	3	-	-
15UMEL504	Fluid Mechanics and Fluid Machinery Lab	0-0-2	1	50	-	-	50	3
15UMEL505	Machine shop Practice	0-0-2	1	50	-	-	50	3
15UMEEXXX	Elective – 1	4-0-0	4	50	100	3		
15UMEEXXX	Elective – 2	4-0-0	4	50	100	3		
	Total	21-6-4	26	400	600	-	100	-

CIE: Continuous Internal Evaluation SEE: Semester End Examination L: Lecture T: Tutorials P: Practical *SEE for theory courses is conducted for 100 marks and reduced to 50 marks

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Electives

Course code	Elective Courses
15UMEE525	Refrigeration & Air conditioning
15UMEE526	Internal Combustion Engines
15UMEE527	Tool Design Engineering
15UMEE528	CAD / CAM
15UMEE529	Theory of elasticity
15UMEE530	Deign of IC engines

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical
*SEE for theory courses is conducted for 100 marks and reduced to 50 marks

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Scheme for VI semester

Course Code	Course Title	Teaching		Examination				
				CIE	Theory (SEE)		Practical (SEE)	
		L-T-P (Hrs/Week)	Credits	Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UMEC600	Finite Element Methods	3-2-0	4	50	100	3	-	-
15UMEC601	Heat Transfer	3-2-0	4	50	100	3	-	-
15UMEC602	Dynamics of Machinery	3-2-0	4	50	100	3	-	-
15UMEL603	Heat Transfer Lab	0-0-2	1	50	-	-	50	3
15UMEL604	CEA / CAM Lab	0-0-2	1	50	-	-	50	3
15UMEL605	Mini Project	0-0-6	3	50	-	-	50	3
15UMEEXXX	Elective – 3	4-0-0	4	50	100	3	-	-
15UMEEXXX	Elective – 4	4-0-0	4	50	100	3	-	-
	Total	17-6-10	25	400	500	-	150	-

CIE: Continuous Internal Evaluation SEE: Semester End Examination L: Lecture T: Tutorials P: Practical *SEE for theory courses is conducted for 100 marks and reduced to 50 marks

Elective courses

Course Code	Elective Courses
15UMEE625	Engineering System Design
15UMEE626	Organizational Behavior
15UMEE627	Jet Propulsion
15UMEE628	Solar Energy
15UMEE629	Advanced Fluid Dynamics
15UMEE630	Tribology & Bearing Design
15UMEE631	Design and Analysis of

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	experiments
15UMEE632	Design & Drawing of Assemblies

V Semester

Course Code	Course Category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	*Max. Marks	Duration in Hrs.	Max. Marks	Duration In Hrs.
18UHUC500	HU	Management, Economics &Intellectual Property Rights	4-0-0	4	50	100	3	-	-
18UMEC500	PC	Theory of Machines	3-2-0	4	50	100	3	-	-
18UMEC501	PC	Design of Machine Elements-II	3-2-0	4	50	100	3	-	-
18UMEC502	PC	Turbo machines	2-2-0	3	50	100	3	-	-
18UMEC503	PC	Renewable Energy Technology	3-0-0	3	50	100	3	--	--
18UMEE5XX	PE	Program Elective-1	3-0-0	3	50	100	3	--	--
18UMEL504	PC	Machine shop Practice	0-0-3	**1.5**	50	--	--	50	3
18UMEL505	PC	Thermal Engg. Lab - II	0-0-3	**1.5**	50	--	--	50	3
18UMEL506	PC	Minor Project-1	0-0-2	1	50	--	--	--	--
18UHUL507	HU	Soft skills/Aptitude	0-0-2	1	50	--	--	--	--
		Total	**18-6-10**	**26**	**500**	**600**		**100**	

BS- Basic Science, **PC**- Program Core
CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical

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*SEE for theory courses is conducted for 100 marks and reduced to 50 marks

Electives

Course code	Elective Courses (PE – 1)
18UMEE521	CAD/CAM **(Computer aided design / Computer aided manufacturing)**
18UMEE522	Non -traditional machining
18UMEE523	CNC Machine technology
18UMEE524	Introduction to composite materials
18UMEE525	Production planning & control
18UMEE526	Advanced Metal Joining Technology
18UMEE527	Fundamentals of Automobile Design **(Ready Engineer by TATA Technologies)**

VI Semester

Course Code	Course Category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	*Max. Marks	Duration in Hrs.	Max. Marks	Duration In Hrs.
18UMEC600	PC	Heat Transfer	3-2-0	4	50	100	3	-	-
18UMEC601	PC	Finite Element Methods	3-2-0	4	50	100	3	-	-
18UMEE6XX	PE	Program Elective-2	3-0-0	3	50	100	3	-	-
18UMEE6XX	PE	Program Elective-3	3-0-0	3	50	100	3	-	-
18UMEO6XX	OE	Open Elective-1	3-0-0	3	50	100	3	--	--

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18UMEL602	PC	Computer Aided Engineering Analysis Lab	0-0-3	1.5	50	--	--	50	3
18UMEL603	PC	Thermal Engg. Lab - III	0-0-3	1.5	50	--	--	50	3
18UMEL604	PC	Minor Project-2	0-0-4	2	50	--	--	50	3
18UHUL605	HU	Soft skills/Aptitude	0-0-2	1	50	--	--	--	--
		Total	**15-4-12**	**23**	**450**	**500**		**150**	

BS- Basic Science, **PC**- Program Core
CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical
*SEE for theory courses is conducted for 100 marks and reduced to 50 marks

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Electives

Course code	Elective Courses (PE-2)	Course code	Elective Courses (PE– 3)	Course code	Elective Courses (OE–1)
18UMEE621	Refrigeration & Air conditioning	18UMEE631	Tool Design Engg.	18UMEO641	Mechatronics
18UMEE622	Nuclear Energy Systems	18UMEE632	Theory of Elasticity	18UMEO642	Total Quality Management
18UMEE623	Advanced Fluid Dynamics	18UMEE633	Mechanical Behavior of Engg. Materials.	18UMEO643	Sustainable Building Technology
18UMEE624	Internal Combustion Engines	18UMEE634	Design and Drawing of Mech. Assemblies	18UMEO644	Work Flow Management
18UMEE625	Cryogenics	18UMEE635	Experimental stress analysis	18UMEO645	Design Thinking
18UMEE626	Alternate Fuels	18UMEE636	Design of IC Engine Components	18UMEO646	Smart Materials and Structures
18UMEE627	Gas Dynamics	18UMEE637	Advanced Automobile Design (Ready Engineer by TATA Technologies)	18UMEO647	Introduction to Scientific programming

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VII Semester

Course Code	Course Category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	*Max. Marks	Duration in Hrs.	Max. Marks	Duration In Hrs.
18UMEC700	PC	Mechanical Vibrations	3 - 2 - 0	4	50	100	3	-	-
18UMEC701	PC	Control Engineering	3 - 2 - 0	4	50	100	3	-	-
18UMEE7XX	PE	Program Elective-4	3 - 0 - 0	3	50	100	3	-	-
18UMEO7XX	OE	Open Elective-2	3 - 0 - 0	3	50	100	3	--	--
18UMEL7XX	PC	Dynamics Lab	0 - 0 - 2	1	50	--	--	50	3
18UMEL702	PC	Major Project Phase-1	0- 0 - 4	2	50	--	--	50	3
18UMEL703	PC	Internship	4 w e e k s	2	50	--	--	50	3
Total			**12 - 4 -6**	**19**	**350**	**400**		**150**	

PC- Program Core, PE-Program Elective, OE- Open Elective and HU- Humanities

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Electives

Course code	Elective Courses (thermal)(G1) (PE- 4)	Course code	Elective Courses (OE – 2)
18UMEE721	Refrigeration & Air conditioning	18UMEE731	Introduction To Aircraft Systems
18UMEE722	Nuclear Energy Systems	18UMEE732	Project Management
18UMEE723	Advanced Fluid Dynamics	18UMEE733	Energy Management
18UMEE724	Internal Combustion Engines	18UMEE734	Design Of Renewable Energy Systems
18UMEE725	Cryogenics		
18UMEE726	Alternate Fuels		

VIII Semester

Course Code	Course Category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	*Max. Marks	Duration in Hrs.	Max. Marks	Duration In Hrs.
18UMEC800	PC	Fluid Power Control	4 - 0 - 0	4	50	100	3	-	-
18UMEE8XX	PE	Program Elective-5	3 - 0 - 0	3	50	100	3	-	-
18UMEE/O8XX	PE/OE	Program Elective-6	3 - 0 - 0	3	50	100	3	--	--
18UMEL801	PC	Technical Seminar/Independent study	0 - 0 - 2	1	50	--	--	--	--
18UMEL802	PC	Major Project Phase-2	0- 0 -12	7	50	--	--	50	3
		Total	**10– 0 - 14**	**18**	**250**	**300**	**--**	**50**	**--**

PC- Program Core, PE-Program Elective and OE- Open Elective

Electives

Course code	Elective Courses (thermal)(G2) (PE- 5)	Course code	Elective Courses (design)(G2) (PE- 6)
18UMEE821	Power Plant Engg.	18UMEE831	Fracture Mechanics
18UMEE822	Design of Heat Exchangers	18UMEE832	Mechanics of Composite Materials
18UMEE823	Hybrid Vehicle Technology	18UMEE833	Modeling & Simulation of Dynamic Systems
18UMEE824	Computational Fluid Dynamics	18UMEE834	Tribology & Bearing Design

Scheme for VII Semester

Course Code	Course Category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	*Max. Marks	Duration in Hrs.	Max. Marks	Duration In Hrs.
18UMEC700	PC	Mechanical Vibrations	3 - 2 - 0	4	50	100	3	-	-
18UMEC701	PC	Control Engineering	3 - 2 - 0	4	50	100	3	-	-
18UMEE7XX	PE	Program Elective-4	3 - 0 - 0	3	50	100	3	-	-
18UMEO7XX	OE	Open Elective-2	3 - 0 - 0	3	50	100	3	--	--
18UMEL702	PC	Dynamics Laboratory	0 - 0 - 2	1	50	--	--	50	3
18UMEL703	PC	Major Project Phase-1	0- 0 - 4	2	50	--	--	50	3
18UMEL704	PC	Internship	4 w e e k s	2	50	--	--	50	3
Total			**12 - 4 -6**	**19**	**350**	**400**		**150**	

PC- Program Core, PE-Program Elective, OE- Open Elective and HU- Humanities

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Electives

Course code	Elective Courses (PE-4)	Course code	Elective Courses (OE–2)
18UMEE721	Power Plant Engineering	18UMEO731	Introduction to Aircraft Industry & Aircraft Systems
18UMEE722	Design of Heat Exchangers	18UMEO732	Project Management
18UMEE723	Hybrid Vehicle Technology	18UMEO733	Energy Management
18UMEE724	Computational Fluid Dynamics	18UMEO734	Design of Renewable Energy Systems
18UMEE725	Advanced Heat Transfer		
18UMEE726	Heating Ventilation and Air Conditioning		
18UMEE727	Battery and Fuel Cell Technology		

Scheme for VIII Semester

Course Code	Course Category	Course Title	Teaching		Examination				
			L-T-P (Hrs /Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	*Max. Marks	Duration in Hrs.	Max. Marks	Duration In Hrs.
18UMEC800	PC	Fluid Power Control	4 - 0 - 0	4	50	100	3	-	-
18UMEE8XX	PE	Program Elective-5	3 - 0 - 0	3	50	100	3	-	-
18UMEE8XX	PE	Program Elective-6	3 - 0 - 0	3	50	100	3	--	--
18UMEL801	PC	Technical Seminar / Independent study	0 - 0 - 2	1	50	--	--	--	--
18UMEL802	PC	Major Project Phase-2	0- 0 -12	7	50	--	--	50	3
Total			**10 - 0 - 14**	**18**	**250**	**300**	**--**	**50**	**--**

PC- Program Core, PE-Program Elective and OE- Open Elective

Electives

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Course code	Elective Courses (PE- 5)	Course code	Elective Courses (PE- 6)
18UMEE821	Operations Research	18UMEE831	Design of Aircraft structures
18UMEE822	Computer Integrated Manufacturing	18UMEE832	Mechanics of Composite Materials
18UMEE823	Organizational Behavior	18UMEE833	Modeling and Simulation of Dynamic Systems
18UMEE824	Industrial Robotics	18UMEE834	Tribology and Bearing Design
18UMEE825	Rapid Prototyping And Rapid Tooling	18UMEE835	Failure Analysis
18UMEE826	Design For Manufacturing And Assembly	18UMEE836	Surface Engineering
18UMEE827	Estimation and Costing in Mechanical Engineering	18UMEE837	Industry 4.0 & Artificial intelligence

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I Semester(PG EAD)

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration in hours
18PEADC100	Computational Methods in Engineering	4-0-0	4	50	100	3		
18PEADC101	Theoretical Stress Analysis	4-0-0	4	50	100	3		
18PEADEXXX	Elective 1	4-0-0	4	50	100	3		
18PEADEXXX	Elective 2	4-0-0	4	50	100	3		
18PEADEXXX	Elective 3	4-0-0	4	50	100	3		
18PEADL131	Design Engineering Lab – I	0-0-3	2	50			50	3
18PEADL132	**Seminar	0-0-2	1	50				
Total		**20-0-5**	**23**	**350**	**500**		**50**	

Course Code	Elective Courses
18PEADE125	Advanced Fluid Dynamics
18PEADE126	Finite Element Methods
18PEADE127	Advanced Material Technology
18PEADE128	Design of Renewable Energy Systems
18PEADE129	Design Optimization
18PEADE130	Design for Manufacture

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I Semester M.Tech.

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration in hours
22PRIC100	Research Methodology and IPR	3-0-0	3	50	100	3	-	-
22PEAC100	Applied Mathematics	4-0-0	4	50	100	3	-	-
22PEADC101	Continuum Mechanics	3-2-0	4	50	100	3	-	-
22PEADC102	Advanced Finite Element Methods	4-0-0	4	50	100	3	-	-
22PEADE11X	Elective 1	4-0-0	4	50	100	3	-	-
22PEADL103	Engineering Analysis Lab -1	0-0-3	2	50	-	-	50	3
22PEADL104	Seminar	0-0-2	1	50	-	-	-	-
22PEAEOA1	**BOS recommended ONLINE course	-	Audit (PP)	-	-	-	-	-
Total		**18-2-5**	**22**	**350**	**500**		**50**	

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Scheme of Teaching and Examination
II- Semester(PG EAD)

Course code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration in hours
18PEADC200	Automobile System Design	4-0-0	4	50	100	3		
18PEADC201	Computational Fluid Dynamics	4-0-0	4	50	100	3		
18PEADEXXX	Elective4	3-0-2	4	50	100	3		
18PEADEXXX	Elective5	4-0-0	4	50	100	3		
18PEADEXXX	Elective6	3-0-2	4	50	100	3		
18PEADL231	Design Engineering lab -II	0-0-3	2	50			50	3
18PEADL232	** Seminar	0-0-2	1	50				
Total		**18-0-09**	**23**	**350**	**500**		**50**	

.

Course Code	Elective Courses
18PEADE225	Dynamics & Mechanism Design Simulation
18PEADE226	Power Plant Design
18PEADE227	Fracture Mechanics
18PEADE228	Heating Ventilation & Air Conditioning (HVAC)
18PEADE229	Advanced Theory of Vibrations
18PEADE230	Advanced Product Design

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II Semester M. Tech.

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration in hours
22PEADC201	Advanced Theory of Vibrations	4-0-0	4	50	100	3	-	-
22PEADC202	Computational Fluid Dynamics	3-2-0	4	50	100	3	-	-
22PEADE2XX	Elective 2	2-0-2	3	50	100	3	-	-
22PEADE2XX	Elective 3	3-0-0	3	50	100	3	-	-
22PEADE2XX	Elective 4	3-0-0	3	50	100	3	-	-
22PEADL203	Engineering Analysis Lab - 2	0-0-3	2	50	-	-	50	3
22PEADL204	Seminar	0-0-2	1	50	-	-	-	-
22PEAEOA2	**BOS recommended ONLINE course	-	Audit (PP)	-	-	-	-	-
Total		**15-2-7**	**20**	**350**	**500**		**50**	

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Electives

Course Code	Elective 2	Course Code	Elective 3	Course Code	Elective 4
22PEADE211	Dynamics & Mechanism Design	22PEADE221	Automobile System Design	22PEADE231	Heating Ventilation & Air Conditioning (HVAC)
22PEADE212	Fracture Mechanics	22PEADE222	Additive Manufacturing Technology	22PEADE232	Power Plant Design
22PEADE213	Experimental Stress Analysis	22PEADE223	Computer Control of Manufacturing System	22PEADE233	Modeling & Analysis of Thermal system

III Semester M. Tech.

Course code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration in hours
18PEADC300	Experimental Techniques	4-0-0	4	50	100	3		
18PEADEXXX	Elective 7	4-0-0	4	50	100	3		
18PEADL328	Internship in Industry/R&D organization / Elective 8	** Min 4 weeks during vacation after 2nd sem	3	50	100	3	50	3
18PEADL329	*** Project phase 1	0-0-15	9	50			50	3
Total		**08/15**	**20**	**200**	**200/ 300**		**100**	

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Course Code	Elective Courses
18PEADE325	Design of Heat Exchangers
18PEADE326	Failure Analysis of Materials
18PEADE327	Robust Design

III Semester M.Tech.

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration in hours
20PEADC301	Experimental Techniques	4-0-0	4	50	100	3		
20PEADE3XX	Elective 5	3-0-0	3	50	100	3		
20PEADE3XX	Elective 6	3-0-0	3	50	100	3		
20PEADE3XX	Elective 7	3-0-0	3	50	100	3		
OR								
20PEADL302	Internship in Industry or R&D organization	** Min 4 weeks during vacation after 2nd sem	3	50	--	--	100	3
20PEADL303	*** Project phase 1	0-0-15	9	50			50	3
Total		**13-0-15/10-4weeks-15)**	**22**	**250**	**400/ 300**		**50/150**	

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Electives

Course Code	Elective 5	Course Code	Elective 6	Course Code	Elective 7
20PEADE311	Advanced Composite Materials and Mechanics	20PEADE321	Design of Heat Exchangers	20PEADE331	Robust Design
20PEADE312	Mathematical Modeling for Engineering Systems	20PEADE322	Scientific Computing	20PEADE332	Failure Analysis of Materials
20PEADE313	Surface Engineering22	20PEADE323	Industry 4.0 & Artificial intelligence	20PEADE333	Industrial Robotics

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15UMEC500	Management, Economics & Intellectual Property Rights	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Patent, copyright and trade secret protection.
2. Role and importance of intellectual property rights in contemporary business environment.
3. Historical development of software patents.
4. Consequences of software piracy on software developers and the role of relevant enforcement organizations.
5. Role of entrepreneurship in modern economy and entrepreneurial opportunities.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Trace the historical development of management thought and approaches to management.	-	1	-
CO-2	Identify the functions of a manager and critically analyze their importance in organizations.	11	2	-
CO-3	Demonstrate the ability to recognize a business opportunity that fits the individual student and launch entrepreneurial career.	10	11	8
CO-4	Explain characteristics of SSI and identify the various Government agencies supporting SSI.	11	6,13	-
CO-5	Define problems and the present environment for existing business and carry out the feasibility studies.	10,11	8	13
CO-6	Explain different forms of intellectual properties rights.	8	-	-

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	PO 13	PO 14
Mapping Level	2	2	-	-	-	2	-	-	-	3	2.7	-	1.5	-

Pre requisites: English, Communication skills.

Course Contents:

I) Management:

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1. Engineering and Management: Historical Development of Engineering, Management, Engineering, Management and Engineering & Management a synthesis. **3 Hrs**
2. Planning, Forecasting and Decision Making: Nature of Planning, the foundation of planning, some planning concepts, forecasting, nature of decision making, management science, tools for decision-making.**3 Hrs**
3. Organizing and staffing: nature of organizing, traditional organizational theory, technology and modern organization structures, staffing technical organization, authority and power; delegation, meeting & committees.**3 Hrs**
4. Motivating: Motivation, leadership, motivating and leading technical professionals. **3 Hrs**
5. Controlling: process of control, financial controls and non-financial controls. **3 Hrs**

II) Entrepreneurship and Economics:

1. Foundations of Entrepreneurship: Meaning of entrepreneur, functions of entrepreneur, types of entrepreneur, concept of entrepreneurship, role of entrepreneurs in economic development, barriers of entrepreneurship.**3 Hrs**
2. Small Scale Industry: Definition, characteristics, objects, role of SSI in economic development, advantages of SSI, steps to start a SSI, impact of liberalization, privatization, and globalization on SSI, definition of ancillary and tiny industry. **3 Hrs**
3. Government and Institutional Support: Nature of support of government, objectives and functions of SISI, SIDBI, DIC, single window agency, KIADB, KSSIDC, KSFC. **3 Hrs**
4. Basic Costs: Material, Labour, Overheads, Fixed and Variable costs, Break Even Analysis, Make or Buy, Buy or Process, shut down or continue decisions. (Numericals) **4 Hrs**
5. Time value of Money: Future and Present value of single sum and Annuities and their Applications like EMI calculation, Net Present Value of an Investment. (Numericals) **5 Hrs**
6. Concept of depreciation: Straight line method, Written down value, Simple problems. **3 Hrs**
7. Preparation of Project: Meaning of project identification, project report, contents and formulation, identification of business opportunities, feasibility studies, types and purpose. **2 Hrs**

III) Protection of Intellectual Property:

1. Introduction: Meaning and forms of intellectual property right, competing rationale for protection, international conventions, world court. **2 Hrs**

2. Copyright: Meaning of copyright, content of copy right, ownership and rights, period of copyright, assignment and relinquishment of copyright, license, infringement of copy right, fair use, offenses and penalties. **2 Hrs**
3. Patents: Concept of patent, patentable inventions, procedure for obtaining patent, rights and obligations of patent holders, infringements and remedies, offenses and penalties. **3 Hrs**
4. Industrial Designs: Definition of design, procedure for registration, rights conferred by registration, infringements, Value of creating Design **3 Hrs**
5. Trademarks – concept, significance, Functions, Features. **2 Hrs**
6. Term Paper on commercializing a hypothetical product/process/software by proper evaluation of relevant existing patents/copy rights. **2 Hrs**

Reference Books:

1. Thomas W. Zimmers - Essentials of Entrepreneurship & small business management, 5th edition, PHI, 2011.
2. Daniel L. Babcock – Managing Engineering and Technology, 4th edition, PHI.
3. Peter Drucker – The Practice of Management
4. Cost Accounting by Khan & Jain .TMH -2013, Edition
5. N.K. Acharya – Text book on Intellectual Property Rights, 4th edition, Asia LawHouse.

15UMEC600	**Finite Element Methods**	**(3-2-0) 4**

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Numerical methods used to solve engineering problems.
2. Skills associated with the principles of FEM.
3. Skills in applying the basic matrix operation to form a global matrix equation and enforce the concept of steps in obtaining solutions for a truss Structures.
4. Interpolation functions to solve beam problems.
5. Skills in applying FEM solution to structural and thermal problems.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain basic terminology, methods, need & applications of FEM	-	1,2	-

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CO-2	Identify, formulate the stiffness matrix, apply boundary conditions & load vector to solve problems for bar & truss element.								1,2		-		-	
CO-3	Identify, formulate the stiffness matrix, apply boundary conditions & load vector to solve problems for beam & CST element.								1,2		-		-	
CO-4	Identify, formulate the stiffness matrix, apply boundary conditions & solve problems on heat conduction & convection.								1,2		-		-	
CO-5	Use commercial software to solve problems.								-		-		5,13	
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	PO 13	PO 14
Mapping Level	2.8	2.8	-	-	1	-	-	-	-	-	-	-	1	-

Pre requisites: Engineering Mathematics, Strength of Materials, Theory of Elasticity

Course Contents:

1. **Introduction:** Need for use of FEM, Advantages, disadvantages and applications of FEM; Matrix Algebra-(Terminology and operations), Gaussian elimination method. **Numerical Integration**- Gauss quadrature, one point and two point formula,1D and 2D integrals.**10L+2T Hrs**

2. **Basics of Theory of Elasticity:** Definitions of stress and strain, strain-displacement relations, stress-strain relations in 2D Cartesian and polar co-ordinates. **5 Hrs**

3. **Continuum methods:** Principal of minimum potential energy; Rayleigh – Ritz method applied to simple problems on axially loaded members, cantilever and simply supported beam; Galerkin method and its application to simple axially loaded problems. **6L+2T Hrs**

4. **Finite Element Method:** Direct approach to discrete systems (Derivation of stiffness matrix by direct method for 2 node bar, 2D truss and beam elements), transformation law, Displacement method; Different co-ordinate systems, Shape functions, Formulation of 2 node bar element, CST element using variational method, stress recovery, Boundary conditions (Single point Constraints only), Elimination and penalty methods of handling boundary conditions. **17L+5T Hrs**

5. **One dimension steady state heat conduction:** formulation of 2 node, 1-D element, using Galerkin method. **4L+1T Hrs**

Reference Books:

1. T. R. Chandrupatla and A. D. Belegundu, 'Introduction to finite Elements in Engineering', 2nd edition, Prentice Hall of India, New Delhi, 2001.
2. R. D. Cook et al, "Concepts and Applications of Finite Element Analysis" 4th edition, Joln Wiley & Sons, inc, 2005.
3. Rao S.S., The finite Element Method in Engineering, 5th edition, Butterworth-Heinemann, 2013.

18UMEC304 Machine Drawing (2-0-2) 3

Contact Hours: 39

Course Learning objectives (CLOs): The objective of this course is to make the student aware of:

1. Importance of making drawings of machine parts as per standards.
2. Detailed drawings of machines parts from assembly drawing and vice versa.
3. Geometrical dimensioning & tolerancing
4. Solid modeling of Screw Jack, Plummer Block, Machine Vise.

Course outcomes (COs):

ID	Description of the course outcome	Mapping to POs (1-12)/PSOs (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Convert the given pictorial views in to orthographic projections of machine parts/objects using drawing conventions	-	1	-
CO-2	Draw or sketch the thread forms & fasteners / draw or sketch the orthographic views of fastener used in fastening two plates.	-	1	-
CO-3	Represent the dimensions on given part with tolerances for fits / and dimensions depicting tolerances for control of geometrical features.	-	1	-
CO-4	Create the parts drawings/assembly drawings in (sectioned) 2D of simple mechanical devices.	-	1	-
CO-5	Create the 3D models of mechanical parts and relevant assembly using the software.	-	5	-

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	PO 13	PO 14
Mapping Level	2	-	-	-	2	-	-	-	-	-	-	-	-	-

Pre requisites: Engineering Drawing, Modeling software awareness, Engineering Materials, Elements of Mechanical Engineering.

Course Contents:

1. **Orthographic views (2D):** BIS conventions. Conversion of pictorial views into orthographic projections of **simple machine parts** with and without section. **6 Hrs**
2. **Thread forms and threaded fasteners: S**ectional views of threads, ISO Metric (Internal & External), and square threads. Assembly of two plates using Hexagonal headed bolt and nut with washer, simple assembly using stud with nut and washer. **6 Hrs**
3. **GD & T:** Part drawings of a press tool representing various geometrical features and their tolerances. **3 Hrs**
4. **Couplings (2D) :** Protected type flange coupling assembly. **3 Hrs**
5. **Assembly Drawings (2D): A**ssembly drawing of– Screw jack (Bottle type) and simple jig. **12 Hrs**
6. **Computer aided 3D modelling: (Solid edge)**
   3D modeling of Screw jack, Plummer block. **9 Hrs**

Reference Books:

1. N.D.Bhatt, 'Machine Drawing', 45th edition, Charotar Publishers, 2008
2. K.R.Gopalkrishna, 'Machine Drawing', 22nd Edition, Subhas Publication 2013
3. 'A Primer on Computer Aided Machine Drawing-2007`, VTU, Belgaum
4. Sham Tickoo,N. Siddeshwar, P. Kanniah, V.V.S. Sastri, 'Auto CAD 2006, for engineers and designers', Dream tech 2005, Tata McGraw Hill, 2006.
5. K C John 'Text Book Of Machine Drawing' PHI Learning Pvt Ltd,2009.

18UMEL407	**Introductory Project**	**(0-0-2) 1**

Contact Hours: 25

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Practical significance of projects.
2. Engineering concepts and its application to real world problems.
3. Literature review for engineering problems
4. Existing solutions to engineering problems.

Course outcomes (COs):

ID	Description of the course outcome: At the end of the course the student will be able to:	Mapping to POs (1-12)/PSO (13-14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Perform literature review for given topic	1,2	-	-

CO-2	Identify problem from literature review	1,2	-	-
CO-3	Establish objectives and methodology for the problem defined.	1,2	3,4	-
CO-4	Analyze the existing solution for the identified problem.	1,2	3,4	5,6,7,12, 14
CO-5	Prepare a report and present their findings using PPT.	10	9	8,12

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	PO 13	PO 14
Mapping level	3	3	2	2	1	1	1	1	2	3	-	1	-	1

Course Contents:

Introductory project is introduced with an objective of understanding and identifying the community expectation in terms of possible Engineering solutions by applying the fundamental knowledge of basic sciences and basic engineering courses. The project shall be engineering oriented in terms of problem definition, related literature survey and existing solutions. The team consisting of 10-12 students shall be asked to identify the problems related to community and try to propose a solution. The faculty members handling the courses for that semester shall guide the students. A committee consisting of minimum 3 faculty members shall evaluate at the end for CIE. There is no SEE for introductory project

18PEADC201 Computational Fluid Dynamics (4-0-0) 4

Contact Hours: 50

Course Learning Objectives (CLOs): This course will enable students to

1. To understand fundamentals of computational fluid dynamics to solve fluid flow and heat transfer problems.
2. To understand dimensionless form of governing equations of fluid flow and heat transfer.
3. Explain FDM and FVM.
4. Solve linear algebraic equations in CFD using numerical methods.
5. Solve fluid flow and heat transfer problems using commercial CFD codes.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to Pos (1-5)		
		Substantial Level(3)	Moderate Level(2)	Slight Level(1)
CO-1	Explain the fundamentals of CFD applied to fluid flow and heat transfer and also discuss on partial differential equations	3	---	---

	and mathematical flow models used in CFD.			
CO -2	To examine fluid flow and heat transfer problems by using Finite Difference method and also error propagation.	1,3	---	---
CO-3	Explain Finite Volume method and analyze fluid flow and heat transfer problems by using Finite Volume method.	1,3	---	---
CO-4	Explain the implicit, explicit, ADI methods and solve the problems using implicit/explicit or ADI method.	3	---	----
CO-5	Explain the essentials of numerical method for CFD.	3	---	---
CO-6	Investigate the fluid flow and heat transfer problems by using theoretical approach and also by using commercial CFD software.	5,3	4	1,2

POs	PO 1	PO 2	PO 3	PO 4	PO 5
Mapping Level	2.3	1	3	2	3

Pre requisites: Fluid mechanics, Partial differential equations, Numerical Methods, Heat transfer**.**

Course Content:

1. **Introduction and Basic Concepts:** Need of CFD as a design and research tool, applications and advantages of CFD,Governing equations (Only discussion on continuity, momentum and energy equations),Dimensionless form of equations; Simplified mathematical models; Hyperbolic, Parabolic & Elliptic systems; Properties of numerical solutions (Consistency, Stability, Conservation, Convergence and Accuracy). Grid generation: structured grids, unstructured grids. **10 Hrs**
2. **Finite Difference Methods**: A differential to algebraic formulation for governing Partial Differential Equations and Boundary conditions, application of FDM to CFD, error propagation. Solution of One-dimensional heat conduction steady state and unsteady state, Two-dimensional steady state heat conduction using FDM. **10 Hrs**
3. **Finite volume method:** Surface & volume integrals; Interpolation & differentiation; Boundary conditions; Central difference and upwind schemes applied to 1-D situation involving convection and diffusion terms, Solution of One-dimensional heat conduction steady state and unsteady stateusing FVM. Calculation of flow field: staggered grid, SIMPLE algorithm. Implicit & Explicit Schemes, Alternate Direction Implicit (ADI) method. **14 Hrs**

4. **Essentials of Numerical Methods for CFD;** Iterative solution of linear algebraic equations for a flow property, iterative methods, applications of iterative methods to CFD, Tridiagonal Systems, under relaxation. **8 Hrs**
5. **Use of commercial software**: Solution of 2D and 3D fluid flow and Heat transfer problems using commercial software. **8 Hrs**

Reference Books:

1. T. J. Chung "Computational Fluid Dynamics" Cambridge Univ. Press, 2002.
2. Farlow "Partial Differential Equations for Scientists and Engineers" John Wiley, 1982.
3. J.H. Ferziger& M. Peric "Computational Methods for Fluid Dynamics", 3rd edition -, Springer, 2002.
4. G.D. Smith, Numerical Solutions of Partial Differential Equations, Finite Difference methods, 3rd ed., -, Oxford University Press. 1986.
5. Suhas V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, Washington, D. C., 1980.
6. H. Versteeg, W. Malalasekra, An Introduction to Computational Fluid Dynamics, 2nd ed., Pearson Education Ltd. 1995.
7. John D. Anderson, Jr., Computational Fluid Dynamics: The basics with applications, McGraw Hill Education (India) Private Limited, New Delhi.1995.
8. Atul Sharma, Introduction to Computational Fluid Dynamics: Development, Applications and Analysis, Ane Books Pvt Ltd, New Delhi. 2017.
9. C. Hirsch, Numerical Computation of Internal & External Flows: The fundamentals of Computational Fluid Dynamics, Elsevier India PvtLtd New Delhi.2012.
10. K. Muralidhar, T. Sundararajan, Computational Fluid Flow and Heat Transfer, 2nd ed., Narosa Publishing House, New Delhi. 1995.

18PEADE229	Advanced Theory Of Vibrations	(3-2-0) 4

Contact Hours: 50

Course Learning Objectives (CLOs):

The objective of this course is to make the students aware of

- How to use the theoretical principles of vibration, and vibration analysis techniques, for the practical solution of vibration problems in engineering design practices.
- Understand the importance of vibrations in mechanical design of machine parts that operate in vibratory conditions.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1-5)		
		Substantial Level(3)	Moderate Level(2)	Slight Level(1)
CO -1	Apply Newton's equation of motion and energy methods to model basic vibrating mechanical systems and solve for the natural frequencies of undamped, damped, forced and Transient vibrating single degree of freedom systems	1,3,4	5	
CO -2	Design of shock isolators, active vibration-control systems and vibration absorbers for given specification and understand vibration measurements and its applications	1,3,4	5	
CO -3	Apply experimental modal analysis and machine-condition monitoring techniques to determine the system characteristics and diagnosis and Investigate free-vibration solutions of string, bar, shaft and beam.	1,3,4	5	2
CO- 4	Understand Random phenomena of vibration using Time averaging, Frequency response function, Probability distribution, Power spectrum, power spectral density and Fourier transforms.	1,3,4		

POs	PO-1	PO-2	PO-3	PO-4	PO-5

Mapping Level	3	1	3	3	2

Course Content:

1. Single degree of freedom systems: Review of free and forced vibration with or without damping, transmissibility. **Multi degree of freedom systems**: Two degree of freedom system, undamped vibration absorbers, generalized coordinates and coordinate coupling, orthogonality principle. **Transient Vibration of single Degree-of freedom systems:** Impulse excitation, Arbitrary excitation, Laplace transform formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation. **14 Hrs**

2. Vibration Control: Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, shock isolation, Dynamic vibration absorbers, Vibration dampers. **Vibration Measurement and applications:** Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis. **10 Hrs**

3. Continuous Systems: Vibrating string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams**. Modal analysis and Condition Monitoring:** Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis. **16 Hrs**

4. Random Vibrations : Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms, FTs and response. **10 Hrs**

Reference Books

1. Theory of Vibration with Application, - William T. Thomson, Marie Dillon Dahleh, ChandramouliPadmanabhan , 5th edition Pearson Education
2. S. Graham Kelly , “Fundamentals of Mechanical Vibration” - McGraw-Hill, 2000
3. S. S. Rao , “Mechanical Vibrations”, Pearson Education, 4th edition.
4. Mechanical Vibration by G.K. Grover. Nem Chand & Bros. 2009
5. S. Graham Kelly , “Mechanical Vibrations”, Schaum’s Outlines, Tata McGraw Hill, 2007.
6. C Sujatha , “Vibraitons and Acoustics – Measurements and signal analysis”, Tata McGraw Hill, 2010.

18PEADE326	Failure Analysis Of Materials	(4-0-0) 4

Contact Hours: 50

Course Learning Objectives (CLOs):

The objective of this course is to make the students aware of

- Understand role of failure in materials for better sustainability of materials and prevent failure of materials by testing under various loads.
- Understand the importance failure modes in materials.

Course Outcomes (COs): At the end of the course the student should be able to

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1-5)		
		Substantial Level(3)	Moderate Level(2)	Slight Level(1)
CO -1	Define failure criteria and different modes of mechanical failure			1,2
CO -2	Use different testing methods to determine failure criteria		3,4	1,2
CO -3	Formulate different statistics in fatigue analysis	4		3,5
CO- 4	Understand the concept of creep, stress rupture and fatigue		3	1,5
CO- 5	Understand the concept of fretting, wear and other failure modes		3	1,5

POs	PO-1	PO-2	PO-3	PO-4	PO-5
Mapping Level	1	1	2	2.5	1

Course Content:

1. The role of Failure Prevention Analysis in Mechanical Design: Introduction, Definition of Design, Some Design objectives, Modes of Mechanical failure, definition of failure mode, failure modes observed in practice. **6Hrs**

2. High Cycle fatigue: The nature of fatigue, Fatigue loading, Laboratory fatigue testing, The S-N-P curves-A basic design tool, factors that affect S-N-P curves, The influence of nonzero mean stress, multiaxial fatigue stresses. **6Hrs**

3. Concepts of cumulative damage, life prediction, and fracture control: The linear damage theory, Cumulative Damage Theories: Henry Cumulative Damage theory, Gatts Cumulative Damage theory, Martin Cumulative Damage theory, Damage tolerance and fracture control **7Hrs**

4. Use of Statistics in Fatigue analysis: Definitions, Population Distributions, Sampling Distributions, Statistical Hypotheses, confidence limits, Properties of good estimators, sample size for desired confidence, probability paper. **6Hrs**

5. Fatigue testing Procedures and statistical interpretation of data: Standard method, Constant stress level testing, response or survival method, Prot method, extreme value method. **6Hrs**

6. Low cycle fatigue: The strain cycling concept, the strain life cycle curve and low cycle fatigue relationships, the influence of nonzero mean strain and nonzero mean stress, cumulative damage in low cycle fatigue, Influence of multiaxial states of stress, Relationship of thermal fatigue to low cycle fatigue. **7Hrs**

7. Creep, stress rupture and fatigue: Prediction of long term creep behavior, Theories for predicting creep behavior, cumulative creep concepts. **6Hrs**

8. Fretting, Fretting fatigue, and Fretting wear: Variables of importance in the Fretting process, Fretting Fatigue, Fretting wear, Fretting Corrosion, minimizing or preventing Fretting damage. Wear, corrosion and other important failure modes. **6Hrs**

Reference Books:

1. Failure of Materials in Mechanical Design: Analysis, Prediction, Prevention, 2nd Edition by Jack A. Collins, John Wiley & Sons, 1983
2. Theory of Materials Failure by Richard M Christensen, Oxford University Press, 2013
3. Failure Analysis of Engineering Materials by Charles R. Brooks, Ashok Choudhury, McGraw Hill Professional, 2002

18PEADE127 Advanced Materials Technology (4-0-0) 4

Contact Hours: 50

Course Learning Objectives (CLOs): This course will enable students to

1. Learn composite properties including longitudinal and lateral moduli, Poisson"s ratio, and shear modulus
2. Acquire the knowledge to determine the generalized stiffness and compliance matrix relating in plane stresses to strains for a composite layer assuming plane stiffness
3. Gain knowledge on powder metallurgy application & know what are surface treatments for materials

Course Outcomes (COs):

Description of the course outcome: At the end of the course the student will be able to:		Mapping to POs(1-5)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO 1	Determine composite mechanical properties from constituent fiber and matrix material properties including longitudinal and lateral moduli, Poisson's ratio, and shear modulus.	3, 4	1	
CO 2	Apply the generalized stiffness and compliance matrix relating in - plane stresses to strains for a composite layer assuming plane stiffness.	3, 4		1

CO 3	Model classical laminated plate theory to determine extensional, coupling, and bending stiffness of a composite laminate.	3	5	
CO 4	Fabricate and detect defect in composite laminates and built up composite structures such as I beams, box beams etc.	3, 4	5	2
CO 5	Apply Concept of Shape Memory, phase transformation mechanism and characterization, properties and applications of Smart Materials.	3, 4	2	
CO 6	Understand the fundamental mechanisms of Nanomaterials and able use in structural materials for the desired properties.	3, 4		5

POs	PO1	PO2	PO3	PO4	PO5
Mapping Level	1.5	1.5	3	3	2

Pre requisites: Engineering Mechanics, Material Science, Applied Mathematics

Course Content:

1. **Introduction to Composite Materials:** Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction. Metal Matrix Composites: Reinforcement materials, Types, Characteristics and selection, Applications. *Macro Mechanics of a Lamina***:** Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems. **13 Hrs**
2. **Micro Mechanical Analysis of a Lamina:** Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems. Experimental Characterisation of Lamina- Elastic Moduli and Strengths. *Failure Criteria:* Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations. **13 Hrs**
3. **Manufacturing and Testing:** Layup and curing - open and closed mould processing, Hand lay-up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair. NDT tests – Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.

Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites. **13 Hrs**

4. Smart Materials: Concept of Shape Memory, crystal structure, phase transformation mechanism and characterization, properties, classification and applications. **5 Hrs**
5. Nano composites/materials: Classification, characterization, materials behavior, fabrication and applications. **6 Hrs**

Reference Books:

1. Krishan K. Chawla "Composite Materials, Science &Engg" 2nd edition, Springer publicat1on.
2. ASM Handbook on Metal Casting - Vol .15, 9th edition, ASM publication
3. ASM Handbook on Powder Metallurgy -Vol 17, ASM publications
4. Mick Wilson, KamaliKannangara, "Nanotechnology – Basic Science and Emerging Technologies" Overseas Press India PrivateLimited, First Indian Edition 2005.
5. V.S.R Murthy, A.K.Jena, K.P.Gupta, G.S.Murthy Structure "Properties of Engineering Materials" Tata McGraw Hill.
6. M.M.Schwartz, "Composite Materials Hand book" McGraw Hill.
7. AUTAR K.KAW, "Mechanics of composite materials" Taylor and Francis group.
8. Rober M. Jones, "Mechanics of Composite Materials" Taylor & Francis, 1998.
9. E.PaulDegarmo, J.T.Black, Ronald A Kohser "Materials and Processing in Manufacturing" 8th Edition – Prentice Hall India.
10. K.K.Chawla, "Composite materials – Science &Engineering" Springer.
11. A.K. Sinha, "Powder Metallurgy" 2nd Edition –. DhanpatRai Publications. Dr. H.K.Shivanand, "Composite Materials" by. Asian Publication.

18UMEC503 Renewable Energy Technology (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Significance of renewable energy sources in present energy scenario of India.
2. Solar radiation geometry solar incident flux.
3. Working of renewable energy systems.
4. Utilization of renewable energy sources in different modes and applications.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain concepts of non-conventional and renewable energy	1	-	7

	systems.			
CO-2	Compute solar radiation flux and power from wind machines	1	2	3, 6
CO-3	Explain the working principles of solar thermal devices.	1	-	7
CO-4	Discuss the working principles of photovoltaic, wind machines and their characteristics	1	-	7
CO-5	Describe the working of biomass gasification, biogas generation and hydrogen energy production storage with applications.	1	-	6, 7

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	3	2	1	-	-	1	1	-	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit - I

Introduction: Energy sources, India's production and reserves of commercial energy sources, need for non-conventional energy sources, energy alternatives, solar, thermal, water power, wind, bio-mass, OTEC, tidal and waves, geothermal, nuclear (Brief descriptions).

Solar Radiation & Geometry: Extra-Terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuses and global radiation, solar radiation data. Latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle, local apparent time, day length. **8 Hrs**

Unit - II

Solar Radiation on flat and tilted surface: Flux on plane surface, expression for the angle between the incident beam and normal to plane surface (no derivation). Beam, diffuse and reflected radiation, expression for flux on a titled surface (no derivations). Numerical examples**.** Measurement of Solar Radiation: Pyranometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working.

Solar Thermal Conversion: Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters, concentrating collectors (cylindrical, parabolic, paraboloid) sensible heat storage, latent heat storage, General description, collector geometry. **8 Hrs**

Unit - III

Wind Energy: Availability of wind energy in India, Power from wind; Site selection, wind machines; Types of wind machines and their characteristic, horizontal and vertical axis wind mills, elementary design principles; coefficient of performance of wind mill rotor, aerodynamic considerations of wind mill design, numerical examples.

Hydrogen Energy: Production, storage and application. **7 Hrs**

Unit - IV

Energy from biomass: Biochemical route: Biogas generation, factors, types of biogas plants **thermo chemical route**. Updraft, down draft and cross draft gasifier. **7 Hrs**

Unit - V

Applications of Renewable energy technologies: Solar water heating. Space heating and cooling; power generation, and refrigeration, Distillation, solar cooker, solar pond, principle of working, Description, principle of working and characteristics, PV cells and applications (Qualitative). **9 Hrs**

Text Books:

1) S.P.Sukatme 'Solar Energy' – TATA McGraw Hill, 1996
2) S. Rao & Dr B.B Parulekar, Energy Technology, 3rd edition, Khanna Publishers, Delhi, 2007.

Reference Books:

1) G.D.Rai "Non-Conventional Energy Sources", 4th edition, Khanna Publishers, New Delhi, 2011.
2) Kreith & Goswami, "Solar Energy", Taylor & Francis, 1999.

18UMEL506	Minor Project - I	(0-0-2) 1

Contact Hours: 26

Course Learning Objectives (CLOs):

The course is included to provide an exposure, focusing more on the domain related problem definitions, building prototypes which can lead to take up the project in the higher semester(s). The work based on using the concepts studied in the core/elective courses studied shall be used to formulate the problem. They are also required to learn to find related material, use appropriate tool to obtain the solution and prepare a report based on the work carried out.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the domain related problem and formulate a problem statement	6	-	9

CO-2	Propose the technical approach towards the solution.	11	4	9
CO-3	Develop physical model or software solution.	4	1, 2, 3, 5, 11	9,10, 12,13
CO-4	Prepare the report in a specified format.	8, 10	-	9, 14

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2	2	2	2.5	2	3	-	3	1	2	2.5	1	1	1

Prerequisites: Nil

Minor project – 1 is undertaken to focus on the domain related problem definitions, building prototypes which can lead to take up the project in the higher semester. The work based on the core courses studied shall be used to formulate the problem. The team consisting of 10-12 students shall be asked to identify the problems related to community and try to propose the solution. A faculty members handling one of the courses for that semester shall guide the students. A committee consisting of minimum 3 faculty members shall evaluate at the end for CIE. There is no SEE for minor project-1.

18UMEE522 Non-Traditional Machining (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Various concepts related to modern machining processes & their applications.
2. The differences between conventional and non-conventional machining processes.
3. Functional understanding of non-traditional manufacturing equipment.
4. Various process parameters and their influence on performance and their applications.

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Enumerate need of non-traditional machining processes and explain Ultrasonic machining process.	1	2,3	-
CO-2	Explain working principles of Chemical and electro-chemical machining processes.	1	2,3	-
CO-3	Discuss working principle and various aspects of EDM process.	1	2,3	-

CO-4	Explain principles of Abrasive Jet Machining & Plasma Arc Machining.	1	2,3	-
CO-5	Describe working principles of LBM & EBM processes.	1	2,3	-

POs/PSOs	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mapping Level	3	2	2	-	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Course contents:

Unit - I

Introduction: Introduction to Non-traditional machining, Need for and Comparison between traditional and non-traditional machining, Classification of Non-traditional machining processes based on nature of energy employed in machining, selection, Advantages, limitations and applications of non-traditional machining processes.

Ultrasonic Machining (USM): Introduction, Equipment and material process, Effect of process parameters: Effect of amplitude and frequency, Effect of abrasive grain diameter, effect of slurry, tool & work material. Process characteristics: Material removal rate, tool wear, accuracy, surface finish, applications, advantages & limitations of USM. **7 Hrs**

Unit - II

Electro Chemical Machining (ECM): Introduction, Principle of electro chemical machining, ECM equipment, elements of ECM operation, Chemistry of ECM. ECM Process characteristics: Material removal rate, accuracy, surface finish. Process parameters: Current density, Tool feed rate, Gap between tool & work piece, velocity of electrolyte flow, type of electrolyte, its concentration temperature, and choice of electrolytes. ECM Tooling: ECM tooling technique & example, Tool & insulation materials. Applications ECM: Electrochemical grinding and electrochemical honing process. Advantages, disadvantages and application of ECG, ECH.

Chemical Machining (CHM): Elements of the process, Resists (maskants), Etchants. Types of chemical machining process-chemical blanking process, chemical milling process. Process characteristics of CHM: material removal rate, accuracy, surface finish, advantages, limitations and applications of chemical machining process. **9 Hrs**

Unit - III

Electrical Discharge Machining (EDM): Introduction, mechanism of metal removal, EDM equipment: spark erosion generator (relaxation type), dielectric medium-its functions & desirable properties, electrode feed control system. Flushing types; pressure flushing, suction flushing, side flushing, pulsed flushing. EDM process parameters: Spark frequency, current & spark gap, surface finish,

Heat Affected Zone. Advantages, limitations & applications of EDM, Electrical discharge grinding, Traveling wire EDM. **8 Hrs**

Unit - IV

Abrasive Jet Machining (AJM): Introduction, Equipment and process of material removal, process variables: carrier gas, type of abrasive, work material, stand-off distance (SOD). Process characteristics-Material removal rate, Nozzle wear, accuracy & surface finish. Applications, advantages & limitations of AJM.

Plasma Arc Machining (PAM): Introduction, non-thermal generation of plasma, equipment mechanism of metal removal, Plasma torch, process parameters, process characteristics. Safety precautions. Safety precautions, applications, advantages and limitations. **8 Hrs**

Unit - V

Laser Beam Machining (LBM): Introduction, generation of LASER, Equipment and mechanism of metal removal, LBM parameters and characteristics, Applications, Advantages & limitations.

Electron Beam Machining (EBM): Introduction, Principle, equipment and mechanism of metal removal, applications, advantages and limitations**. 7 Hrs**

Text Book:

1) P.C Pandey and H S Shah, “Modern Machining Process”, McGraw Hill Education India Pvt. Ltd., 2000.

Reference Books:

1) Production technology HMT McGraw Hill Education India Pvt. Ltd 2001
2) Dr. Amitabha Bhattacharyya, “New Technology”, The Institute of Engineers India, 2000.
3) M. Adithan, “Modern Machining process”, 2002.
4) Gary F. Benedict, “Nontraditional manufacturing processes”, Marcel Dekker, Inc. 1987.

18UMEE523	CNC Machine Technology	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. The principles, constructional features, programming, tooling and work-holding devices in CNC machine tools

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain evolution and principles of CNC machine tools.	-	1	-
CO-2	Describe constructional features of CNC machine tools.	-	2	-
CO-3	Discuss the drives and positional transducers used in CNC machine tools.	-	3	-
CO-4	Write simple programs for CNC turning and machining centers and generate CNC programs for popular CNC controllers	1	-	5
CO-5	Describe tooling and work holding devices for CNC machine tools	-	1, 3	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.3	2	2	-	1	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit – I

Introduction to CNC Machine Tools: Evolution of CNC Technology, principles, features, advantages, applications, CNC and DNC concept, classification of CNC Machines – turning centre, machining centre, grinding machine, EDM, types of control systems, CNC controllers, characteristics, interpolators– Computer Aided

Inspection. **8 Hrs**

Unit - II

Structure of CNC Machine Tool: CNC Machine building, structural details, configuration and design, guide ways – Friction, Anti friction and other types of guide ways, elements used to convert the rotary motion to a linear motion – Screw and nut, recirculating ball screw, planetary roller screw, recirculating roller screw, rack and pinion, spindle assembly, torque transmission elements – gears, timing belts, flexible couplings, Bearings. Sensors used in CNC - LVDT, Capacitive, inductive, power monitoring systems. **9 Hrs**

Unit - III

Drives and controls: Spindle drives – DC shunt motor, 3 phase AC induction motor, feed drives –stepper motor, servo principle, DC and AC servomotors, Open loop and closed loop control, Axis measuring system – synchro, synchro - resolver, gratings, moiré fringe gratings, encoders, inductosysn, laser interferometer. **7 Hrs**

Unit - IV

CNC Programming: Coordinate system, structure of a part program, G & M Codes, tool length compensation, cutter radius and tool nose radius compensation, do loops, subroutines, canned cycles, mirror image, parametric programming, machining cycles, programming for machining centre and turning centre for well known controllers such as Fanuc, Heidenhain, Sinumerik etc., generation of CNC codes from CAM packages. **8 Hrs**

Unit - V

Tooling and Work Holding Devices: Introduction to cutting tool materials – Carbides, Ceramics, CBN, PCD–inserts classification- PMK, NSH, qualified, semi qualified and preset tooling, tooling system for Machining centre and Turning centre, work holding devices for rotating and fixed work parts, economics of CNC, maintenance of CNC machines. **7 Hrs**

Text Book:

1) Suk–Hwan Suh, Seong–Koon Kang, Dae–Hyuk Chung & Ian Stroud, “Theory and Design of CNC Systems” Springer, 2nd Edition, 2008.

References Books:

1) HMT, "Mechatronics”, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2005.
2) James Madison, “CNC Machining Hand Book”, Industrial Press Inc., 1996.
3) Ken Evans, John Polywka & Stanley Gabrel, “Programming of CNC Machines”, Second Edition – Industrial Press Inc, New York, 2002
4) Peter Smid, “CNC Programming Hand book”, Industrial Press Inc., 2000
5) Berry Leathan – Jones, “Introduction to Computer Numerical Control”, Pitman, London, 1987.

6) Radhakrishnan P “Computer Numerical Control Machines”, New Central Book Agency, 2002.
7) Rao P.N., "CAD/CAM", Tata McGraw-Hill Publishing Company Limited, New Delhi, 2002.
8) Warren S. Seamers, “Computer Numeric Control”, Fourth Edition – Thomson Delmar, 2002.

18UMEE524 Introduction to Composites Materials (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. composite properties including longitudinal and lateral moduli, Poisson’s ratio, and shear modulus
2. To determine the generalized stiffness and compliance matrix relating in plane stresses to strains for a composite layer assuming plane stiffness
3. Powder metallurgy applications & know what are surface treatments for materials

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain the basic terms and concepts of composite materials.	-	1, 4	3
CO-2	Use generalized Hooks law for evaluating stiffness and compliance matrix for different conditions	3	4	1
CO-3	Evaluate mechanical properties of composite materials.	3	4	1
CO-4	Explain fabrication and machining methods of composite laminates.	-	4	2, 3
CO-5	Discuss the defects in composite laminates, and applications of composites in various fields.	-	4	2

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	1.3	1	2	2	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Course Content:

Unit - I

Introduction to Composite Materials: Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber

composites, laminated composites, Particulate composites, Prepegs, and sandwich construction. Metal Matrix Composites: Reinforcement materials, Types, Characteristics and selection, Applications**.** **8 Hrs**

Unit - II

Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.

9 Hrs

Unit - III

Micro Mechanical Analysis of a Lamina: Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems. Experimental Characterization of Lamina- Elastic Moduli and Strengths. *Failure Criteria:* Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsai-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations. **8 Hrs**

Unit - IV

Manufacturing and Testing: Layup and curing - open and closed mould processing, Hand lay-up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair. **7 Hrs**

Unit - V

NDT tests: Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.

Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites. **7 Hrs**

Text Book:

1) Autar K. Kaw, “Mechanics of composite materials” CRC press, 2nd Edition, 2006

Reference Books:

1) Robert M. Jones, “Mechanics of Composite Materials” Taylor & Francis, 1998.
2) Krishan K Chawla, “composite materials” Springer, 2nd edition, 1998.

18UMEE525	Production Planning and Control	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. The problems and opportunities faced by the operations manager in manufacturing and service organizations.
2. Apply PPC concepts in a various areas like marketing, accounting, finance, engineering, personnel management, logistics, etc.
3. To integrate operations concepts with other functional areas of business
4. To understand the PPC function in both manufacturing and service organizations.

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Recognize the objectives, functions, applications of PPC and forecasting techniques.	1	-	-
CO-2	Apply different Inventory control techniques for manufacturing sectors.	1	2	3, 5
CO-3	Solve routing and scheduling problems	3	-	1
CO-4	Solve problems of aggregate production planning techniques.	-	4	1
CO-5	Describe way of integrating different departments to execute PPC functions	-	-	5

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2	2	2	2	1	-	-	-	-	-	-	-	-	-

Pre requisites: Nil

Course Contents:

Unit - I

Introduction: Definition – Objectives of production Planning and Control – Functions of production planning and control – Elements of production control – Types of production – Organization of production planning and control department – Internal organization of department.

Forecasting: Importance of forecasting –Types of forecasting, their uses – General principles of Forecasting –Forecasting techniques– qualitative methods- Jury/Expert Method, Survey of Expert opinion method , Sales force composite method, Survey of buyers intention method and quantitative methods- Simple average, moving average, smoothing coefficient, Least Square method.

8 Hrs

Unit - II

Inventory Management: Functions of inventories – relevant inventory costs – ABC analysis – VED analysis – EOQ model – Inventory control systems – P– Systems and Q-Systems Introduction to MRP-I, MRP-II & ERP, JIT inventory, Kanban systems. **8 Hrs**

Unit - III

Routing: Definition – Routing procedure –Route sheets – Bill of material – Factors affecting routing procedure.

Scheduling: Definition – Activities-Difference with loading, Scheduling types: Forward, Backward scheduling, Job shop scheduling methods – Arrival pattern, processing pattern, number of workers available, machine varieties available, Priority rules for job sequencing FIFO, SPT, SOT, EDD, STR, CR, LISO, Random Orders. Scheduling Techniques Gantt Charts, LOB, Johnson's job sequencing rules- n jobs on 2machines, n jobs on 3 machines, n jobs on m machines.

8 Hrs

Unit - IV

Line Balancing: Introduction, objectives, terms related to line balancing, procedures, simple problems

Aggregate Planning: Introduction, Inputs to aggregate planning, strategies-Line strategy, chase strategy, capacity options, demand options. **8 Hrs**

Unit - V

Dispatching: Centralized and Decentralized Dispatching- Activities of dispatcher – Dispatching procedure –follow-up – definition – Reason for existence of functions – types of follow up, applications of computer in production planning and control. **7 Hrs**

Text Book:

1) Stephen N Chapman "The Fundamentals of Production Planning and Control", Pearson education, 2009.

Reference Books:

1) Elwood S Buffa & Rakesh K Sarin, "Modern Production & Operations management", 8th edition, John Wiley, 2016.
2) Samuel Eilon, "Elements of Production Planning and Control", Universal Publishing Corporation.1999.
3) Jain K C & L. N. Agarwal, "Production, Planning and Control & Industrial Management", 8th edition, Khanna Publishers, 1999.

18UMEE526	Advanced Metal Joining Technology	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Overview of welding process and it advances including types and their applications.
2. Modeling and simulation of operas.
3. Mechanical aspects of processes.
4. Welding defects causes, remedies and methods to detect.

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1-12)/ PSOs (13,14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain the working principles of various advanced welding processes.	-	1	2
CO-2	Select appropriate welding procedure, consumables and welding parameters for various engineering applications.	-	1	2
CO-3	Identify various defects in weld using different testing methods and remedial measures.	-	1	2
CO-4	Apply the principles of welding metallurgy, thermal molding and simulation to produce defect free welding for different materials.	-	5	3

POs/PSOs	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mapping Level	2	1	1	-	2	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit - I

Overview of welding processes and their classification, types of joints, edge preparation, weld symbols, weld nomenclature, bead geometry, power density, heat sources, welding techniques – linear and orbital. Arc characteristics. Voltage – current characteristics. Types of welding manipulators and their applications. **8 Hrs**

Unit - II

Advances welding processes: submerged arc, TIG, MIG, electro-slag, ultrasonic, electron beam and laser beam welding thermite welding, underwater welding. Case studies and applications – industrial automotive and aerospace.

Thermal modeling and simulation of welding processes – governing heat transfer equations and boundary conditions for various types of welding processes. Estimation of cooling rates. **8 Hrs**

Unit - III

Prediction of mechanical properties. Micro/macro-structures of weldments and heat-affected zone. Prediction of weld defects such a crack, segregation, lack of fusion. Modeling and simulation of pulsed arc processes. **7 Hrs**

Unit - IV

Solidification behavior of fusion weld: structural zones, epitaxial growth, weld pool shape and columnar grain structures. Welding of metals – steels, stainless steels, aluminium, copper, nickel and titanium alloys. **7 Hrs**

Unit - V

Microstructures of weldments: Segregation of alloying elements. Impact of micro/macro-structures and segregation on mechanical properties. Pre-and post-treatment. Effects of heat flow on residual stresses and distortion. Welding tests. **Welding defects:** causes and remedies. Methods of testing welding – mechanical, Pressure and leak testing. Inspection methods – visual, magnetic, ultrasonic, x-ray and radiography. **9 Hrs**

Text Books:

1) Khanna O. P. "A text book on welding Technology", Dhanpat Rai and Sons, New Delhi, 2013.
2) Parmar R. S. "Welding process and Technology", Khanna publishers, Delhi,1992.

Reference Books:

1) Little R. L. "Welding and Welding Technology", Tata McGraw Hill Publishing company Limited New Delhi, 1989.
2) Grong O. "Metallurgical Modeling of Welding", The institute of Materials, 2nd edition, 1997.
3) Kou S. "Welding Metallurgy", John wiley publications, New York, 2nd Edition. 2003.

18UMEE527	**Fundamentals of Automobile Design** (Ready Engineer by TATA Technologies)	(2-0-2) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objective of this course is to make the student aware of:

1. Theoretical concepts of automotive industry.
2. Design and development automotive systems.
3. Die and Fixtures Design.
4. Explain Industrial Design and its importance

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:	**Mapping to POs(1-12)/ PSOs (13,14)**		
	Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**

CO-1	Identify the importance of design and styling for Automotive Product Development	1	-	-
CO-2	Apply fundamental concepts on the bonnet design	-	2	-
CO-3	Investigate the concept of FEA and NVH in the process of model creation and analysis.	3	-	-
CO-4	Investigate the Die and fixture design process	3	-	-
CO-5	Discuss on different methods of sheet metals process and its use in automobile.	-	2	-
CO-6	Describe various methods of operations performed on sheet metals fixtures	-	2	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2	3	3	-	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit - I

Automotive design and development cycle: Introduction to styling, Design, Design Examples, Industrial Design, applications. Typical Product Life Cycle, Automotive Design Process (Design Process for production release), Design Studio Process or Product Conceptualization process, case study, Computer Aided Styling (CAS) Surfaces or Digital Clay Models, Class A Surfaces, Role of Class A Surface Engineer, Requirements for Class A Surface, Case Studies for Class A Surfaces, Step by Step Process for Bonnet Class A Surface Creation. Good Design & its examples.

Practical sessions:

Session1: Exercise to obtain the outer surface (CAS) of a bonnet based on car style

Session2: Writing the Requirement Specification of car bonnet (idea is to provide this as input to source a supplier)

Session3: Basic introduction to CAD & suitable software (Siemens NX, Catia)

4L+3P Hrs

Unit - II

Introduction to styling: Function of a bonnet, Inputs for the bonnet, Design procedure- Develop Hood Package Layout, Develop Typical Sections, Define Block Surfaces in 3D, Define Dynamic Clearance Surfaces in 3D, Define Hood Structural Members, Computer Aided Engineering(CAE) 1(Durability, crash), Panel Detail Design, Define Body Assembly Process, CAE 2(Durability, crash, Individual pane l level). Design Updating and Detailing Prototypes, Design Updating and Production Release.

Practical sessions:

Session 1: CAD design of a bonnet - 1

Session 2: CAD design of a bonnet – 2

Session 3: Application of CAE simulation on bonnet CAD (air flow, water flow, etc) **4L+3P Hrs**

Unit - III

Introduction to CAD, CAM & CAE: Finite Element Analysis(FEA),Noise Vibration and Harshness(NVH), Dura, Crash, Occupant Safety, CFD Implicit vs. Explicit Solvers, Degrees of Freedom, Stiffness matrix, Pre -Post and Solver; Types of Solvers, Animations, Durability: Oil Canning on Hood, Scope of Work, NVH: Constrained Modal Analysis on Hood, Scope of Work, Loading, Boundary Conditions, Results & Conclusion, Crash: Vehicle Crashworthiness, Energy Management Biomechanics, Head Impact Analysis on Hood, Importance of Failure Criteria, Von Mises Stress.

Practical sessions

Session 1: Application of CAE simulation on bonnet CAD (strength & stiffness, debt resistance)
Session 2: Fixture design
Session 3: Assembly& disassembly considerations for components (after sales, service) **4L+3PHrs**

Unit - IV

Sheet metal design and manufacturing: Introduction to Sheet metal design and manufacturing cycle, Simultaneous Engineering (SE) feasibility study, Auto body and its parts Important constituents of an automobile, different types of Sheet metal processes, Types of draw dies, Draw Model development, Considerations while developing draw model, Forming simulations, Material properties Forming Limit Curve (FLD), Pre- processing, Post Processing, Sheet Metal Formability – Simulation.

Practical sessions:

Session 1: Design for manufacture of plastic parts (mould flow, draft angle etc)

Session2: Bench marking a bonnet by studying competitor data (2 or 3 examples) **8L+2PHrs**

Unit - V

Die design: Requirements, Sheet metal parts and their operation like Cutting, Non-cutting etc., Presses, and Various elements used in die design. Function of each element, Different types of dies, working of dies .Real life 3D experience of Die design.

Fixture design: Requirements, definition, operation and elements of fixture design, Different types of welding processes used for fixture, Body Coordinates 3- 2-1 principle, need for Fixture, Design Considerations. Specification of product using GD&T in the Fixture design. Fixture Elements. typical operations in Sheet metal Fixture using Manual/Pneumatic/Hydraulic fixture, typical Unit Design for Sheet metal parts (Rest/Clamp/location/Slide/Dump units/base), types of Fixture (Spot welding/Arc welding/Inspection Fixture/Gauges)

Practical sessions:

Session 1: Example Design Failure mode and Effect Analysis (DFMEA) practical 1 - how to analyze risk & define counter measures.

Session 2: Example DFMEA practical 2 - how to analyse risk & define counter measures. **6L+2P Hrs**

Reference Books:

1) Banabic, D. (n.d.). “Sheet Metal Forming Processes”, Constitutive Modelling and Numerical Simulation.
2) Klocke, F. (n.d.). “Manufacturing Processes 4 Forming”, Retrieved from http://www.springer.com/series/7858.
3) Mikell P. Groover “Fundamentals Of Modern Manufacturing”, Materials, Processes, and Systems Fourth Edition,
4) H-Point The Fundamentals of Car Design & Packaging, copy write 2008 by Design Studio press.
5) Delmar, Cengage Learning, “Jig and Fixture Design”, Fifth Edition Edward G. Hoff man, 2004.
6) Mohammed A. Omar, “The Automotive Body Manufacturing Systems And Processes”, John Wiley & Sons Ltd, Edition first published 2011,

18UMEL604	Minor Project - 2	(0-0-4) 2

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

5. Practical significance of projects.
6. Engineering concepts and its application to real world problems.
7. Manufacturing problems associated with fabrication.
8. Creativity as an essential component of engineering application.

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify, formulate & solve a problem using basic engineering principles.	1,2	4	12
CO-2	Design the machine parts, components of a system that meets particular requirement.	3	7	6,12
CO-3	Use the software tools to prepare & analyze models or prototypes and conduct simulation using it.	5,13	2	-
CO-4	Use the machine tools to prepare models or prototypes.	5,13	2	-

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CO-5	Work in teams and communicate effectively for in time completion of projects.	10	8,11,12	-
CO-6	Prepare a report and PPT based on the project work.	13,14	9,10,11	-

POs/PSOs	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mapping level	3	2.4	3	2	3	1	2	2	2	2.5	2	1.4	3	3

Prerequisites: Nil

Course Contents:

Every student is advised to conduct a mini project covering relevant thrust areas of Mechanical Engineering and to device and analyze the problem in consultation with a faculty guide of his choice. There will be at least 3 presentation phases culminating with a final project presentation to the examiners.

Note: Activities for self-study to be initiated by the guide.

18UHUL605 Soft Skills/Aptitude (0-0-2) 1

Contact Hours: 26

Course Learning Objectives (CLOs):

This is included with the objectives of improving the communication skills, proficiency in English language and aptitude ability of the student to enhance the employability.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain the significance of communication in the profession.	-	10	-
CO-2	Use the English language with proficiency	-	10	12
CO-3	Solve Aptitude related problems	-	9	12
CO-4	Demonstrate the competency in the placement activities.	-	9	-

POs/PSOs	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mapping Level	-	-	-	-	-	-	-	-	2.0	2.0	-	-	-	-

Prerequisites: Nil

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Course Contents:

Training on communication skills, proficiency in English language and aptitude ability involving the internal and external resource.

Soft skills / Aptitude: This is included with an objective of improving the communication skills, proficiency in English language and aptitude ability of the student. This is a credit course and aimed to enhance the employability. Both the internal and external resource persons shall be engaged in imparting the related knowledge and shall have only CIE as the evaluation component as. The mode of evaluation shall be as per the guidelines by the central authorities.

18UMEE621	Refrigeration and Air-Conditioning	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Vapour compression systems of single stage and multi stage and carnot Vapour compression cycle and effect of volumetric efficiency and pressure change and optimum inter mediate pressure, sub-cooling and super heating on COP.
2. Principles of Vapour absorption and water, air refrigeration.
3. Uses and properties of refrigerants also application of secondary refrigerants.
4. Principles of psychrometry and basic processes of air conditioning.
5. Cooling and heating load calculation for air-conditioning and refrigeration.
6. Applications of refrigeration.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Discuss basic concepts & various methods in refrigeration and air-conditioning.	1,2	-	-
CO-2	Compute performance parameters for single & multi stage VCR.	1,2	-	-
CO-3	Explain VAR system and air conditioning processes.	-	1,2	-
CO-4	Estimate heating and cooling loads for refrigeration and air conditioning systems.	1,2	-	3

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CO-5	Discuss non-conventional refrigeration systems, refrigerants and its applications.	-	-	1,2

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.8	2.8	1	-	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit - I

Introduction: Basic Definition of Refrigeration and Air-Conditioning, History of Refrigeration and Air-Conditioning**,** Necessity of Refrigeration and Air-Conditioning, Different methods of Refrigeration.

Air Refrigeration: Carnot refrigeration cycle, Brayton refrigeration cycle- Aircraft refrigeration system – necessity Classification- Basic aircraft refrigeration cycle- Boot strap air refrigeration system Regenerative air refrigeration system- reduced ambient air refrigeration system. **9 Hrs**

Unit - II

Single and Multi stage VCR: Vapour Compression Refrigeration Cycle Single stage systems - Effect of pressure changes on COP- Effect of sub-cooling and super heating- actual vapour compression cycle. Use of p-h chart, Refrigeration property tables. Two stage with given intermediate pressure- Effect of volumetric efficiency on multi staging- optimum inter stage pressure- Cascade refrigeration system- multi evaporator system- Booster system.

Water Refrigeration: Introduction- principle of operation - Centrifugal refrigeration- Steam jet refrigeration. **8 Hrs**

Unit - III

Vapour Absorption system: Simple and Improved Ammonia absorption systems- Maximum COP- Lithium Bromide absorption system- Electrolux system.

Psychrometry of Air Conditioning Processes: Mixing process- Basic processes in conditioning of air- Psychrometric process in Air conditioning equipment- Simple air conditioning system- State and mass rate of supply air- summer air conditioning – Apparatus dew point- winter air conditioning.

8 Hrs

Unit - IV

Cooling and Heat load Calculations: Selection of design temperatures- Sources of heat load- Capacity of Refrigeration system- Cooling load

calculations- Heat transfer through structure- Solar radiation- Electrical appliances- Infiltration and Ventilation- Heat generation inside the conditioned space- Air conditioning and cooling loads and apparatus selection- Heating load calculations. **7 Hrs**

Unit - V

Nonconventional Refrigeration Systems, Refrigerants and Applications: Basic principle of operation, Thermodynamic analysis, advantages and disadvantages of Vortex tube, Pulse tube and Thermoelectric refrigeration system;

Refrigerants: Introduction**,** Classification- Nomenclature- Desirable properties- Common refrigerants and Secondary refrigerants. **Applications:** All the year–round air conditioner, Air conditioning in Transport: Air conditioning systems for automobiles, Air conditioning systems for trains, Comfort Air Conditioning: Residential air conditioning, Commercial air conditioning; Industrial air conditioning and Refrigeration: Chemical and process industries, Dairy plants and Petroleum refineries, Food processing plants. **7 Hrs**

Text Book:

1) Manohar Prasad, ‘‘Refrigeration and Air-conditioning’’, 2nd edition, Wiley Eastern Publication, 2010

Reference Books:

1) C.P.Arora, ‘‘Refrigeration and Air-conditioning’’, 2nd Edition, Tata McGraw Hill Publication, 2000.
2) L.N.Mishra-Vani, ‘’Refrigeration and Air-conditioning’’, Educational Books, New Delhi- 1985.
3) Jordon and Priester, ‘’Refrigeration and Air conditioning’’, PHI Publication, 1995.

18UMEE622	Nuclear Energy Systems	(3-0-0) 3

Contact Hours: 39

Course Objectives (CLO's): The objectives of this course are to make the student to learn:

1. Explore the engineering design of nuclear power plants using the basic principles of reactor physics, thermodynamics, fluid flow and heat transfer.
2. Reactor principles, nuclear safety, and reactor dynamic behavior.
3. Standards of radiation protection and need for nuclear waste disposal.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain the fundamentals of atomic structure and nuclear power generation.	1	-	-
CO-2	Discuss nuclear reactions and radiations with matter.	1	2	-
CO-3	Describe nuclear reactor theory.	-	1,2	-
CO-4	Enumerate engineering design considerations of nuclear power.	-	1, 2	-
CO-5	Identify the environmental effects due to nuclear radiation.	-	1	7
CO-6	Explain the general principles of nuclear reactor safety and protection.	1	-	6,7

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	3	2	-	-	-	1	1	-	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit - I

Nuclear energy fundamentals: Atomic structure, and radio isotopes, radio activity, nuclear fission, nuclear fission reactors. History of reactor development, reactors for power production. **7 Hrs**

Unit - II

Nuclear reactions and radiations: Radio activity, interaction of alpha and beta particles, with matter, interaction of beta particles with matter, interaction of neutrons with matter, neutron cross section. **8 Hrs**

Unit - III

Nuclear reactor theory: The neutron cycle, critical mass, neutron diffusion, the diffusion equation, flux distribution in a spherical and rectangular core, slowing down of neutrons, reactor period, transient conditions and reflectors. **8 Hrs**

Unit - IV

Engineering Considerations of Nuclear Power: Extension of theory to design, design criteria, selection of materials, reactor fuel, moderator materials, coolant system, reactor control and operation, fuel preparation, reprocessing of spent fuel. **8 Hrs**

Unit - V

Environmental effects and safety: Radiation hazards, radiation monitoring, radio waste treatment systems, reactor shielding. General principles of reactor safety, reactor protection system, reliability and risk assessment. **8 Hrs**

Text Book:

1) Samuel Glasstone and Alexander Seasonske, “Nuclear reactor engineering”, 3rd edn, CBS Publishers, USA.

Reference Books:

1) Glenn Murphy, “Elements of Nuclear Engineering”, John Wiley and sons Inc.
2) K.Sriram, “Basic Nuclear Engineering”, Wiley eastern Ltd., 1990.
3) W.Marshall, “Nuclear Power Technology”, Vol 1,2 & 3, Oxford University Press, New York, 1983.

18UMEE624	Internal Combustion Engines	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Different types of internal combustion engines, principles of operations, parameters that define engine performance and efficiency aspects.
2. Thermodynamics of theoretical cycles.
3. Importance of fuel-air mixture preparation processes and fuel supply system in gasoline and diesel engines.
4. Spark-ignition (SI) and compression ignition (CI) engine combustion, SI and CI engine knock, and combustion chambers.
5. Diesel combustion and diesel engine emissions formation and control.

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Discuss fuel-air cycles and combustion phenomena in SI engines.	1	2	-
CO-2	Explain air-fuel ratios and combustion phenomena in CI engines.	1	2	-
CO-3	Describe the need for spray pattern in CI engines and working of Electric, Hybrid and Autonomous vehicles	1, 3	2	-
CO-4	Compare effect of alternative fuel properties on the performance of IC engine and fossil fuels.	-	1	-
CO-5	Evaluate emission characteristics and methods used to reduce emission.	1	2, 6	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.8	2	3	-	-	2	-	-	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit - I

Introduction: Fuel Air Cycles, Variations in specific heat, Dissociation, Simple problems.

Combustion in S. I. Engines: Ignition limits- Stages of combustion in S. I. Engine, Effect of engine variables on ignition lag and flame propagation,

Detonation – theory of detonation, Effect of engine variables on detonation, Octane number, Control of detonation, S.I. engine combustion chambers. **7 Hrs**

Unit - II

Combustion in C.I Engine: Stages of combustion in C. I. engine, Variables affecting delay period, Diesel knock, Effect of engine variables on knocking, methods of controlling knocking, cetane number, Diesel engine combustion chambers, Difference between SI and CI Engine.

Fuel supply system in SI engines: mixture requirements for steady and transient operations, Fuel consumption loop, carburetor, Petrol injection – MPFI, numerical problems, **8 Hrs**

Unit - III

Fuel supply system in CI engines: Requirements of a diesel injection system, Types of injection system, Fuel pump, Fuel injectors, fuel nozzles, quantity of fuel per cycle, Size of orifice, Effect of orifice diameter, Fuel spray behavior, Overall spray structure, Spray penetration, Droplet size distribution, spray formation, Injection pressure, and spray direction, CRDI system.

Testing of an I.C Engines: Performance parameters, Measurement of air and fuel consumption, Heat balance sheet, and Numerical problems.**8 Hrs**

Unit - IV

Electric, Hybrid and Autonomous vehicles: Meaning of Electric, Hybrid and Autonomous vehicle, Architecture of series, parallel and combined series-parallel hybrid electric merits and demerits, Components of Electric and hybrid vehicles, Regenerative braking, Drive systems, AC and DC motors, Motor Controllers and Control System, Automotive Battery Requirements, Classification of Batteries, type of Batteries (Li-Ion, Metal-hydride, Ni-Cd etc), Battery materials.

Alternative Fuels for an I. C. engine: SI and CI Engine fuels properties. Alternative fuels for SI and CI engine. Performance of SI and CI engine when operated on alternative fuels. Dual fuel engine, factors affecting combustion of dual fuel engine, Advantages of Dual fuel engine. Homogeneous charged compression ignition engines. **8 Hrs**

Unit - V

Pollution from I. C. Engines: Pollutants from I.C engines, Emission standards, Effect of mode of operation, Diesel emissions – Diesel smoke and control, diesel odor and control, Comparison of diesel and gasoline emissions.

Emission control devices: Exhaust gas recirculation, Water injection, Thermal reactor, Catalytic converter, Control of engine and operating parameters to control emissions. **8 Hrs**

Text Book:

1) John B Heywood, “IC Engine Fundamentals, International Editions”, Automobile Technology Series, McGraw hill, 2010.

Reference Books:

1) M. L. Mathur & R. P. Sharma, “I.C. Engines”, Dhanpat Rai & Sons, New Delhi, 2011.
2) Edward F.Obert, “", Harper & Row Publishers”, New york, 1973.
3) Willard W. Pulkrabek, “Engineering fundamentals of the I. C. Engines”, PHI Pvt. Ltd., New Delhi, 2002.
4) M. Ehsani, Y. Gao, S. Gay and Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC Press, 2005.
5) Iqbal Husain, “Electric and Hybrid Vehicles” Design Fundamentals, Second Edition, 2nd Edition, CRC Press, 2010.
6) Sandeep Dhameja, “Electric Vehicle Battery Systems”, Newnes, 2000.

18UMEE625	Cryogenics	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Principles of cryogenics and applications.
2. Low temperature properties of engineering materials.
3. Gas separation and gas purification and production of ultralow temperature.
4. Vacuum technology cryogenics insulation fluid storage and applications.

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1-12)/ PSOs (13,14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain different cryogenic terms, processes and material properties.	1	-	2
CO-2	Discuss various cryogenic systems and thermodynamics of ideal systems.	1,2	-	-
CO-3	Describe the importance of effectiveness of heat exchanger used in cryogenics.	1,2	-	-
CO-4	Illustrate various methods of measurements in cryogenics.	-	1,2,3	-
CO-5	Compare various insulation systems, vacuum pumps and suspension systems.	1,2	-	-
CO-6	Discuss cryogenics applications in the field of food preservation, medicine, super conductors and space technology.	1,2	-	-

POs/PSOs	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mapping Level	2.8	2.5	2	-	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit – I

Introduction and Low temperature properties of engineering materials: Cryogenic Systems. Applications and Areas of Cryogenic Engineering. Mechanical properties, Thermal properties, Electrical properties.

Gas liquefaction Systems: Introduction The thermodynamically Ideal system Production of low temperatures- joule Thomson Effect Adiabatic expansion Liquefaction systems for Air/Nitrogen/Oxygen- Simple Linde - Hampson System, Pre cooled LH System, Claude System, Kapitza System. Comparison of Liquefaction Systems. **8 Hrs**

Unit – II

Gas liquefaction Systems and heat exchanger: Liquefaction Systems for hydrogen, (pre cooled linde-hampson and pre cooled Claude systems),helium liquefaction systems (collin's system and Simon's system) Heat exchanger effectiveness.

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Gas separation: Thermodynamics ideal separation system, Principles of gas separation. Linde single column air separation. Linde double column air separation. **8 Hrs**

Unit – III

Gas purification systems: Absorption**,** Adsorption Process and Combined purification method.

Cryogenic refrigeration systems: Ideal Refrigeration system (Isothermal source), Joule Thomson Refrigeration systems, Solvay Refrigerator. Magnetic Refrigeration systems, He3_He4 Dilution refrigerator. **7 Hrs**

UNIT – IV

Measurement systems: Resistance thermometers Thermocouples Thermistors Gas Thermometry. Liquid level sensors, vacuum pumps, Ion Pumps, Diffusion pumps,

Cryogenic Insulation: Heat transfer due to conduction, Evacuated porous insulation powder& Fibers, Opacified powder insulation, Gas filled powders &Fibrous materials, Multilayer super-insulation, Composite insulation.**8 Hrs**

Unit – V

Cryogenic fluid storage and suspension systems: Design of cryogenic fluid storage vessels Inner vessel Outer vessel Insulation Suspension system.

Application of cryogenic systems: Cryogenic applications for food preservation, Biology and Medicines, Super conductive devices, space technology. **8 Hrs**

Text Books:

1) Mamata Mukhopadhyay, “Fundamentals of Cryogenic Engineering”, PHI publications, 2010.
2) Randal Barron, “Cryogenics Systems”, oxford Press, 1985.

Reference Books:

1) Marshall Sitting D.Van Nostrand, “Cryogenics, Research and application co.inc Princeton New Jersy, 1989.
2) Klaus D. Timmerhaus & Thomas M. Flynn, Cryogenic process Engineering, Plenum Press, New York & London, 1989.
3) Thomas M Flynn, Marcel Dekker, Cryogenic Engineering Inc. N.Y.Basal, 1997.

18UMEE626	Alternative Fuels	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Basic principles of energy sources.
2. Energy analysis and understanding the basic mechanism of energy transfer such as solar wind biomass and hydrogen energy.
3. Multidimensionality and dependence of variables on performance parameter.
4. Thermal conditions on surfaces and obtain mathematical relations connected to temperature, efficiency and conversion.

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:	**Mapping to POs(1-12)/ PSOs (13,14)**		
	Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**

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CO-1	Outline the need for energy, sources, scope and their applications.	1	3	-
CO-2	Explain the production methods and properties of liquid fuels for IC engines.	1	2	-
CO-3	Discuss the utilization of solar PV cells for Electric & Hybrid vehicles.	1	2	3
CO-4	Describe the methods of production of gaseous fuels and their properties.	1	1,3	-
CO-5	Explain the impact of using alternate fuels on environment and economy.	1	1,2	7, 8

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.7	2	1.5	-	-	-	1	1	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit - I

Introduction: Sources of fuels, Need for renewable, sustainable and alternative fuels, Sources of alternative fuels for SI and CI engines, advantages and justification, potential of different fuels, Status of renewable energy in India. Scope of availability of fossil fuel in future. Significance of air fuel ratio and equivalence ratio, proximate and ultimate analysis. Advanced techniques for determining the composition and structure of alternate fuels. Numericals.

Biofuels: Different type's liquid (Alcohols and biodiesels) and gaseous fuels (LPG, CNG, hydrogen, biogas and producer gas), properties and its utilization for SI and CI engines. Comparison between conventional and alternative fuels. **8 Hrs**

Unit - II

Vegetable oils as fuels: Various vegetable oils and their properties, Different methods of using vegetable oils in engines (Blending, preheating and Transesterification and emulsification of Vegetable oils), Production of biodiesels of different origin using conventional and advanced fuel processing methods, Properties of biodiesel in comparison with diesel fuel.

Alcohols as fuels: Production methods of alcohols (Methanol/Ethanol). Properties of alcohols in comparison with gasoline and diesel fuel. Methods of using alcohols in CI and SI engines. **8 Hrs**

Unit - III

Solar Power: Solar cells for energy collection. Storage batteries, layout of solar powered automobiles. Advantages and limitations.

Electric & Hybrid Vehicles: Layout of an electric vehicles, advantages & limitations. Systems components, advantages, I. C. engine and batteries powered vehicles, Drive systems, Batteries and its types (high energy and power density batteries). Vehicles with electrical drive system, Series and parallel HVs. **8 Hrs**

Unit - IV

Gaseous fuels: Production of Biogas and producer gas, Gasifiers, types and its merits and demerits, Properties of gaseous fuels, Factors affecting the gas yield, Properties and its utilization in I. C. engines

Hydrogen as engine fuel: Production methods of hydrogen. Properties of hydrogen, Combustive properties of hydrogen. Advantages of hydrogen as fuel, Hydrogen storage, material difficulties. Problems associated with hydrogen as fuel and solutions. Different methods of using hydrogen in SI and CI engines. Hydrogen storage – safety aspects of hydrogen. **8 Hrs**

Unit – V

Performance and emission characteristics of an I C engine. Influence of fuel properties on the performance and emission characteristics of SI and CI engine operating on biofuels. Dual fuels engine, Advantages of dual fuel engine, Factors affecting the dual fuel engine

Emissions: Emission standards, global warming, regulated and unregulated emission levels, control of emission levels from I C engines. Environmental assessment of alternative fuels, Economic considerations of alternative fuels. **7 Hrs**

Text Book:

1) Dr. S. Thipse, “Alternate Fuels: Concepts, Technologies and Developments”, 1st Edition, Jaico Publishers, 2010.

Reference Books:

1) Richard L. Bechtold, “Alternative Fuels Guidebook - Properties, Storage, Dispensing, and Vehicle Facility Modifications”, SAE International Publisher, United States, 1999.
2) Michael Frank Hordeski, “Alternative Fuels: The Future of Hydrogen”, Third Edition, CRC press, Taylor and Francis publications, 2013.
3) Ganeshan, “Internal Combustion Engines” 2nd edition, Tata McGraw Hill publisher. New Delhi, India.
4) G.D.Rai, “Non-Conventional energy sources”, Khanna publications, Sixth Edition, India.
5) Richard Folkson, “Alternative Fuels and Advanced Vehicle Technologies for Improved Environmental Performance”, 1st Edition, Elsevier – Wood head Publishing Limited publisher.

6) Jan C.J. Bart N Palmeri Stefano Cavallaro, “Biodiesel Science and Technology”, 1st Edition, Elsevier – Wood head publishing Limited publisher, 2010.
7) The Biogas Handbook-Science, Production and Applications, Wood head Publishing Limited publisher, 2013.
8) Arthur Wellinger Jerry Murphy David Baxter, “The Biogas Handbook-Science: Production and Applications”, 1st Edition, Elsevier – Wood head publishing Limited publisher, 2013.

18UMEE627	Gas Dynamics	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Basic principles of 1-D steady state compressible flow and adiabatic flow.
2. Normal and oblique shock parameters applied to gases.
3. Differential form of equation applied to compressible flow and its linearization.
4. Measurement of parameters for supersonic flow.

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1,12)/ PSO (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Enumerate 1-dimensional steady flow equation for compressible flow	-	1,2	-
CO-2	Apply the concepts of compressible flow and shock phenomenon	1,2	-	-
CO-3	Apply differential equation of motion for oblique shock and expansion wave formation.	1,2	-	-
CO-4	Evaluate the parameters high speed flow.	-	1,2,3	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**

Mapping Level	2.5	2.5	2	-	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit - I

One Dimensional Compressible Flow: Energy, Momentum, continuity and state equations, velocity of sound, Adiabatic steady state flow equations, Flow through converging, diverging passages, Performance under various back pressures. Numericals. **8 Hrs**

Unit - II

Normal Shock: Prandtl Meyer equation and Rankine – Hugonoit relation, Normal shock equations: Property ratios in terms of upstream Mach number, Numericals, Moving Normal Shock wave. **8 Hrs**

Unit - III

Oblique shocks and Expansion waves: Prandtl equation and Rankine – Hugonoit relation, Normal shock equations, Pitot static tube, corrections for subsonic and supersonic flows, Oblique shocks and corresponding equations, Hodograph and pressure turning angle, shock polars, flow past wedges and concave corners, strong, weak and detached shocks, Flow past convex corners, Prandtl –Meyer expansion function, Reflection and interaction of shocks and expansion, waves, Families of shocks. Flow with Friction and Heat transfer. **8 Hrs**

Unit - IV

Differential Equations of Motion for Steady Compressible Flows: Basic potential equations for compressible flow. Linearization of potential equation-small perturbation theory. Methods for solution of nonlinear potential equation – Introduction, Method of characteristics, Boundary conditions, Pressure coefficient expression, small perturbation equation for compressible flow - Prandtl, Glauret and Geothert's rules - Ackert's supersonic airfoil theory, Von-Karman rule for transonic flow, Lift, drag pitching moment and center of pressure of supersonic flow **8 Hrs**

Unit - V

Measurements in High speed Flow: Types of subsonic wind tunnels - Balances and measurements - Interference effects- transonic, Supersonic and hypersonic wind tunnels and characteristic features, their operation and performance - Shock tubes and shock tunnels - Free flight testing - Measurements of pressure, velocity and Mach number -Flow visualization methods of subsonic and supersonic flows. **7 Hrs**

Text Books:

1) John D Anderson, “Modern Compressible Flow”, Mc Graw Hill,3rd edition,2012,
2) Radhakrishnan, E., “Gas Dynamics”, Prentice Hall of India,5th edition,2014,

Reference Books:

1) Ascher.H. Saphiro, “Dynamics and Thermodynamics of Compressible fluid flow”, John Wiley & Sons, 1st edition, 1977,
2) Yahya, S.M., “Fundamentals of Compressible flow”, NEW AGE, 2009,
3) H.W. Liepmann and A. Roshko, “Elements of Gas Dynamics”, Dover Publications Inc, 2003,
4) Hodge B. K, Koenig K, “Compressible Fluid Dynamics with Computer Application”, 1st edition, Prentice Hall, New York (1995).
5) Clancy L. J.,” Aerodynamics”, Shroff Publishers, 2006.
6) Zucrow, M.J. and Anderson, J.D., “Elements of gas dynamics”, McGraw - Hill Book Co., New York, 1989.

18UMEE631 Tool Design Engineering (3-0-0) 3

Contact Hours: 39

Course Objectives: The objectives of this course are to make the student to learn:

1. Tools for sheet metal component manufacturing and plastic components manufacturing
2. Methods of locating and clamping work pieces while machining
3. Design of Jigs & Fixtures
4. Design of press tools for sheet metal parts manufacturing
5. Design of moulds for plastic parts manufacturing

Course outcomes (Cos): At the end of the course Students will be able to

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain the basic concepts of press tool principles and parameters.	1	-	-
CO-2	Illustrate the method of locating and clamping of work pieces.	-	1	-
CO-3	Illustrate the working of drill jigs, mould, press tools and milling fixtures.	-	1	-
CO-4	Draw the strip lay out as related to press tools.	-	1	-
CO-5	Design press tools, jigs, fixtures, and moulds with sketches and drawings.	1	3	2
CO-6	Calculate the parameters required for designing the tools.	1	-	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.5	1	2	-	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

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Course Contents:

Unit - I

Introduction to tool design: Tooling, requirements of a tool designer, General tool design procedure, Drafting and Design techniques, Tool Making practice,

Locating and clamping methods: Introduction, Basic principles of location, Locating methods and Locator pins/plugs, Basic principles of clamping, Types of clamps. **7 Hrs**

Unit - II

Design of drill Jigs: Introduction, Need and advantages of jig, Types of drill jigs- Latch/leaf jig, Plate jig, Channel jig, Box jig, Tumble jig, Post jig, Indexing jig, Drill bush & types, Design of drill jig for the given component.

7 Hrs

Unit - III

Design of Fixtures: Introduction, Need and advantages of fixtures, Types of fixtures- Vise fixture, Milling fixture, Lathe fixture, Boring fixture, Broaching fixture, Grinding fixture. **7 Hrs**

Unit - IV

Design of sheet metal Blanking and Piercing Dies: Introduction, Die cutting operations, Power presses, press terminology, Cutting action in punch and die operation, Die clearance, Cutting force and Press force calculation, Types of Press tools- Progressive, Compound, Combination, Inverted dies, Die design fundamentals, Blanking and Piercing die design construction, Strip layout, Economy factor, Design exercises on blanking and piercing dies for simple components. **9 Hrs**

Unit – V

Design of Bending and Drawing Dies: Introduction, Bend allowance-formula, Spring back, Methods to overcome spring back, Blank length calculation, Bend force calculation, Principle of V bending- Air bending and bottoming out, Edge bending, U- bending, Drawing Dies, Drawing operations, Metal flow, Variables affecting metal flow, Determination of blank size and drawing force, Single action and double action draw dies.

Introduction to Design of Moulds: Moulding process, Types of Plastics-Thermoplast and Thermoset resins, Classification of moulding- Injection moulding, Compression moulding, Details of Injection Moulding Tool (single cavity, two cavity mould). **9 Hrs**

Assignments: To prepare designs on the following as Term Work sheets:
1) Jig Design **2)** Fixture Design **3)**Press Tool Design

Text Book:

1) C. Donaldson, G.H.LeCain, V.C. Goold, “Tool design”, Third Edition, Tata McGraw Hill Pubication.1976.

Reference Books:

1) M H A Kempster, “Introduction to Jig and Tool Design”, ELBS, 1974.
2) J.R. Paquin & R.E. Crowley, “Die Design Fundamentals”, Industrial Inc Press
3) R.G.W. Pye; “Injection Mould Design”, 3rd Edition, Godwin Books, 1983.

18UMEE632	Theory of Elasticity	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Basics of stresses, strains, equilibrium, compatibility and governing equations.
2. Solving problems in plane stress, plane strain, torsion and bending.
3. Concepts of three-dimensional problems.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Discuss the fundamentals of stress, strain and their relations with numerical problems.	1,2	3	12
CO-2	Solve problems in Cartesian co-ordinates using Biharmonic Equation and Airy’s Stress Function.	1,2	-	-
CO-3	Solve problems on Thick cylinders & shrink fits using polar coordinates.	1,3	4	-
CO-4	Compute Stress concentration and stresses for various structural members.	1,2	-	3
CO-5	Derive torsional equation for solving problems on circular, non-circular and thin tubes.	1,2	-	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	3	3	2	2	-	-	-	-	-	-	-	1	-	-

Prerequisites: Nil

Course Contents:

Unit - I

Stress: Definition notation and sign convention of stress; Equilibrium equations; Stress components on an arbitrary plane.

Principle stresses- maximum shear stress, octahedral stresses- boundary conditions. **8 Hrs**

Unit - II

Strain: Definitions – strain - displacement relations - compatibility equations Principal strains.

Generalized Hooke's law; Generalized Hooke's law in terms of engineering elastic constants; strain energy. **8 Hrs**

Unit - III

Two dimensional problems in Cartesian co-ordinates: Plane stress and plane strain conditions- Bi-harmonic equation- Investigation of Airy's stress function for simple beam problems- Solution for cantilever beam under end load and simply supported under uniformly distributed load.

Stress concentration in an infinite plate with circular hole subjected to uniaxial load, General equations in polar co-ordinates: Thick cylinder under pressure – Analysis of shrink fit, Stresses in rotating Hollow and solid discs and cylinders. **8 Hrs**

Unit - IV

Torsion of circular and elliptical bars; Membrane analogy.

Torsion of thin open sections, torsion of thin tubes. **7 Hrs**

Unit - V

Uniqueness theorem - Saint Venant's Principle - Principle of super position - Reciprocal theorem.

Rayleigh - Ritz method; Galerkin method; Reciprocal theorem and Castiglione's theorems. **8 Hrs**

Text Book:

1) L. S. Srinath, "Advanced Mechanics of solids", 3rd edition, Tata McGraw-Hill book Company, 2009.

Reference Books:

1) S. P. Timoshenko and J. N. Goodier, "Theory of Elasticity", 3rd edition- McGraw Hill- New York- 2010.
2) C. T. Wang, "Applied Elasticity" McGraw Hill Book Co., 1953.
3) T. G. Sitharam & L. Govinda Raju, "Applied Elasticity", Interline Publishing, 2008.

18UMEE633	Mechanical Behavior of Engineering Materials	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): This course will enable students to

1. Learn stress strain properties in simple tension, compression, shear, impact, fatigue and creep
2. Acquire the knowledge to determine the stress strain behaviour under the influence various loadings.
3. Gain knowledge in utilizing tensile, compression, shear, impact, fatigue and creep properties in machine design.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO 1	Explain Stress Strain Properties in Tension and Compression with numerical problems.	1,	2, 3	-
CO 2	Apply generalized bending and torque equations to find corresponding stresses.	1	2,3	-
CO 3	Characterize fatigue properties for fixed amplitudes.	1, 3	-	-
CO 4	Find impact strength properties and its use in machine design.	1	3	2
CO 5	Estimate material damping properties for simple loadings and creep.	1,3	-	2

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	3	1.5	2.4	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Nil

Course Contents:

Unit - I

Static Stress Strain Properties in Tension and Compression: Introduction, Nominal Stress strain properties in simple tension and compression, Mechanical properties for elastic and plastic range, True stress strain properties in simple tension, Utilization of simple tension and compression properties in design, Simple numerical problems. **8 Hrs**

Unit - II

Static stress strain properties for shear and bending: Shear properties, Static stress properties in direct shear, Static shear properties using solid circular torsion specimen and thin walled circular torsion specimens, Determination of the shear stress strain relation from the torque twist diagram of a solid bar, Utilization of static shear properties in machine design, Numerical problems.

Bending Properties, Static stress strain properties in bending, Utilization of static bending properties in design, Numerical problems. **8 Hrs**

Unit - III

Fatigue properties: Nature of Fatigue failures, Types of fatigue loading, simple fatigue properties for Fixed Amplitudes, Numerical problems, Influence of stress concentration on fatigue strength, Factors influencing fatigue strength, Utilization of fatigue properties in machine design. **8 Hrs**

Unit - IV

Shock and Impact properties: Introduction, Analysis of impact stresses and strains using approximate methods, Analysis of impact stresses and strains using experimental methods, Shock and impact properties, Notched bar impact properties, Utilization of impact properties in machine design.

8 Hrs

Unit - V

Damping, Temperature and Creep properties: Introduction, Determination of Material Damping, Material Damping properties for simple stresses.

Temperature and Creep properties: Stress strain properties, influence of low and high temperature**,** Static creep properties, utilization of temperature and creep in design, Material Testing equipment's, methods of load application, Load measurement, static testing machine, Torsion testing machine, strain gages. **7 Hrs**

Text Book:

1) Thomas H. Courtney, "Mechanical Behavior of Materials", 2nd Edition. Mc Graw Hill Publications, 2012.

Reference Books:

1) Gere and Timoshenko, "Mechanics of Materials", Second edition, CBS Publishers and Distributors, New Delhi. 2004.
2) Joseph Marin, "Mechanical Behaviors of Engineering Materials", Prentice Hall OF India Pvt. Ltd, New Delhi, 1966.

18UMEE634 Design & Drawing of Mechanical Assemblies (3-2-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Types of engineering materials used in power transmission elements.
2. Concepts of designing various machine elements and assemblies.
3. Usage of design data handbook, BIS standards and draw manually the production drawing.

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Interpret the Geometrical dimensioning and tolerance symbols in technical drawings.	10	-	3
CO-2	Design components of IC Engine, Power transmission & Material handling equipment.	1,3	2	6
CO-3	Use standards & codes for designing, selecting and drawing parts and their assemblies	3	10	1,8
CO-4	Select materials and configurations based on manufacturing, cost and assembly criteria	1	11	3,9

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.3	2	2.3	-	-	1	-	1	1	2.5	2	-	-	-

Prerequisites: Nil

Course Contents:

Unit - I

Drawing & sketching conventions & standards – BIS **6 + 3T Hrs**

Unit - II

Design & drawing of engine components: Piston, Connecting rod, Valve gear mechanism **5 + 4T Hrs**

Unit - III

Design and drawing of load handling equipment: Screw jack, Crane hook, Overhead crane hoist **5 + 4T Hrs**

Unit - IV

Assembly drawings –Couplings – (any one) **4+ 2T Hrs**

Unit – V

Assembly drawings –Clutches & brakes (any one) **4+ 2T Hrs**

Examination pattern (3 Hrs – 100 marks)

Any two question to be answered out of four questions each question carries 50 marks and should include complete design and drawing to dimension on the drawing sheet.

Text Books:

1) Prof. K.R. Gopalakrishna, "Machine Drawing", Subash Publishers, Bangalore, 2005.
2) Robert L. Norton, "Machine Design an integrated approach". 2nd edition, Pearson Education, Asia University Press, 2013.

Reference Books:

1) N.D. Bhatt & V.M. Panchal, "Engineering Drawing". 50th edition, Charotar Publishing House, Gujarat, 2010.
2) Harry Peck, "Designing for Manufacture", Pitman Publishing, 1973.

18UMEE635	Experimental Stress Analysis	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Method of electrical strain gauges to study and characterize the elastic behavior of solid bodies.
2. Measure displacement and perform stress strain analysis of mechanical systems using electrical resistance strain gauges.
3. Photo elastic method to study and characterize the elastic behavior of solid bodies.
4. Stress strain behavior of solid bodies using methods of coating
5. Stress strain analysis of solid bodies using the methods holography

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain basic concepts of generalized measurement system and electrical resistance strain gauges	-	1,2	-
CO-2	Estimate strains using strain gauge rosettes	1,2	-	3
CO-3	Describe theory of photo elasticity for finding principal stresses.	1,2	-	-
CO-4	Discuss three-dimensional Photo elasticity and Birefringent coating for finding stresses	1,2	-	3
CO-5	Explain brittle coating techniques and their use in photoelastic materials	-	1,2	3

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.6	2.6	1	-	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit - I

Introduction: Definition of terms, Calibration, Standards, Dimension and units generalized measurement system. Basic concepts in dynamic measurements, system response, distortion, impedance matching, Analysis of experimental data, cause and types of experimental errors. General consideration in data analysis.

Electrical Resistance Strain Gages: Strain sensitivity in metallic alloys, Gage construction, Adhesives and mounting techniques, Gage sensitivity and

gage factor, Performance Characteristics, Environmental effects, Strain Gage circuits. Potentiometer, Whetstone's bridges. **8 Hrs**

Unit - II

Strain Analysis Methods: Two element, three element rectangular and delta rosettes, Correction for transverse strain effects, Stress gage, Plane shear gauge, stress intensity factor.

Force, Torque and strain measurements: Mass balance measurement, Elastic element for force measurements, torque measurement. **8 Hrs**

Unit - III

Photo elasticity: Nature of light, Wave theory of light - optical interference, Stress optic law – effect of stressed model in plane and circular polariscopes, Isoclinic's & Isochromatics, Fringe order determination Fringe multiplication techniques , Calibration photoelastic model materials.

Two Dimensional Photo elasticity: Separation methods: Shear difference method, Analytical separation methods, Model to prototype scaling, Properties of 2D photoelastic model materials, and Materials for 2D photo elasticity. **9 Hrs**

Unit - IV

Three Dimensional Photo elasticity: Stress freezing method, Scattered light photo elasticity, Scattered light as an interior analyzer and polarizer, Scattered light polariscope and stress data Analyses.

Photoelastic (Birefringent) Coatings: Birefringence coating stresses, Effects of coating thickness: Reinforcing effects, Poisson's, Stress separation techniques: Oblique incidence. **7 Hrs**

Unit - V

Brittle Coatings: Coatings stresses, Crack patterns, Refrigeration techniques, Load relaxation techniques, Crack detection methods, Types of brittle coatings, Calibration of coating. Advantages and brittle coating applications. **7 Hrs**

Text Books:

1) Srinath L.S "Experimental stress Analysis", TATA Mc Graw Hill.
2) Sadhu Singh, "Experimental Stress Analysis", Khanna publisher.
3) Dally and Riley, "Experimental Stress Analysis", McGraw Hill.

Reference Books:

1) M. M. Frocht, "Photo elasticity", Vol I and Vol II, John Wiley & sons.
2) Perry and Lissner,"Strain Gauge Primer".
3) Kuske, Albrecht & Robertson, "Photo Elastic Stress Analysis", John Wiley & Sons.

4) Dave and Adams, “Motion Measurement and Stress Analysis”.
5) Holman, “Experimental Methods for Engineers”, Tata McGraw-Hill, 7th Edition, New York, 2007.

18UMEE636	Design of IC Engine Components	(3-0-0)3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Different types of internal combustion engines and different parts of SI and CI engine.
2. Design of crack shaft, piston, connecting rod, camshaft, piston rings, fly wheel, combustion chambers and clutches.
3. Different conventional and modern type of fuel injection systems used in SI & CI Engines.
4. Design of effective cooling systems used in IC engines and heat exchanges.

5. Designing suitable emission control systems to meet stringent emission norms.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Design combustion chamber and cylinder head for both SI & CI Engines.	3	1,2	-
CO-2	Design crank shaft, cam, connecting rod, piston for different types of automobiles.	3	1,2	-
CO-3	Design clutch, flywheel and cooling systems.	3	1,2	-
CO-4	Explain the use of fuel injector & cooling system.	-	1	-
CO-5	Discuss hazards and emission control of IC engines.	-	1	7

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2	2	3	-	-	-	1	-	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit - I

Classification of I C Engines, SI & CI Engines. Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines. **8 Hrs**

Unit - II

Design of piston, piston pin & piston rings for small family cars **7 Hrs**

Unit - III

Classification & design of connecting rod, Classification & Design of crankshafts. **8 Hrs**

Unit - IV

Design of inlet and exhaust cam profile, Design of Clutch: Single & multi-plate Clutches, Dry and wet clutches. Design of Flywheel – Single and multi-cylinder engines. **8 Hrs**

Unit - V

Cooling System, Spray formation, Fuel injection system,

Emission Control: Common emission control systems, measurement of emissions, exhaust gas emission testing. **8 Hrs**

Text Book:

1) V B Bhandari “Design of Machine Elements”, Tata McGraw-Hill, 2008.

Reference Books:

1) Newton Steeds & Garratte, The Motor Vehicle Lliffee & Sons Ltd., London
2) Kolchin, “I. C. Engines”, MIR Publications, Moscow
3) N.K.Giri, Automobile Mechanics, Khanna Publications, 1994

18UMEO643	**Sustainable Building Technology**	**(3-0-0) 3**

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Need for energy conservation in building sector and basic
2. Space conditioning needs and evaluation in building
3. Energy efficiency in lighting and material of the building
4. Zero energy and rating systems related to building

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Review the energy use trends in Building sector and need for energy conservation in building	-	1,2	-
CO-2	Evaluate space condition and lighting loads in building	-	1,2	-

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CO-3	Calculate the embodied energy of building material, U and R values for green building	-	1,2	-
CO-4	Apply the guidelines of green rating systems on a building	-	-	1,7

POs/PSOs	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mapping Level	1.8	2	-	-	-	-	1	-	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit - I

Introduction: Energy use patterns in world and Indian sectors. Energy scenario in India and Indian building sector. Need for energy management in building sector. Basic terms used in buildings, energy efficiency measures in building.

Heating ventilation and air conditioning: Introduction, principles of HVAC, human comfort, Indoor air quality and air change rates in building ventilation requirement, Energy efficient HVAC systems. **8 Hrs**

Unit - II

Air-conditioning: Psychrometry, working of winter and summer air condition systems, classification of air condition system, c.o.p of air condition systems, evaluation of cooling load and heating load for space condition.

8 Hrs

Unit - III

Energy efficiency in lighting: basic terms in lighting, design of lighting for building, lighting requirements in built in spaces. Design of electric and day lighting devices, roof top PV systems **8 Hrs**

Unit - IV

Energy efficient building materials, Embodied energy, Operational energy in Building and Life cycle energy. Energy efficient materials for window, wall and roof, sol-air temperature, U value and R value, solar heat gain coefficient

8 Hrs

Unit - V

Green building rating systems: energy and built in environment. Waste management in building, brief study of ECBC, IGBC LEED and GRIHA rating.

7 Hrs

Reference Books:

1) Arora and Domkundwar, “A course on Refrigeration and air conditioning”, Dhanpatrai and sons, 2018.
2) Jan F Kreider, Peter S Cutriss, “Heating and cooling of building, principals and practice of energy efficient design”, CRC Press, 2018.
3) ASHRAE (American Society of Heating and Ventilation Engineers) Standard 62.2P Ventilation and acceptable indoor air quality in low rise residential building, 2002.
4) B.L.Thereja, “Text book of Electrical Technology”, Vol.3, S.Chand 2018.
5) Venkatarama Reddy, B. V., and. Jagadish, K., S. “Embodied energy of common and alternative building materials and technologies”. Energy and Buildings, 2003.
6) Ministry of Power, Energy Conservation Building Code 2018, Revised Version, Bureau of Energy Efficiency, 2018, TERI-GRIHA’s Green Design practices (www.teriin.org/bcsd/griha/griha.html)

18UMEO644	Work Flow Management	(3-3-0) 3

Contact Hours: 39

Course Learning Objectives: The objectives of this course are to make the student to learn:

1. Overview of automotive industry development till date.
2. Develop 3S and V map.
3. Heijunka planning and control maps.

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Discuss technological developments in manufacturing arena of automotive industry till date	6	7	11
CO-2	Develop 3S and V-map of manufacturing industry	1,3	13	6,8,9,10, 12
CO-3	Develop Hejunka planning and control maps	1,3	4	13

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**

Mapping Level	3	-	3	2	-	2	2	1	1	1	1	1	1.5	-

Prerequisites: Audit course on observation skills, safety measures in a manufacturing plant during previous semester for minimum two sessions of 3 hours each (Maximum of 20 students to be offered for this course after screening)

Course Content:

Unit - I

Observation skill demonstrations, writing skills in 4W-1H format (What, Where, When, Who, How), **2L+3T Hrs**

Unit - II

The rise and fall of Mass Production and the rise of Lean Production, demonstration with case studies. **3L+2T Hrs**

Unit - III

The total framework of Toyota Production System with case studies, Introduction to building blocks of TPS: JIT, KANBAN, KAIZEN, POKA YOKE, 5S, PDCA. **5L+ 4T Hrs**

Unit - IV

Development of 3S map with case studies minimum three plant/shop floor visits. **6L+ 4T Hrs**

Unit - V

Hejunka planning and control maps with fine tuning of case studies from 3S map. **6L+4T Hrs**

Reference Books:

1. VLCI Course material by CII
2. James P. Womack, Daniel T. Jones, and Daniel Roos “Machine that changed the world” ,MIT.
3. Yasuhiro Monden “Toyota Production System”, CRC Press.

18UMEO645	Design Thinking	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Discipline—design thinking—that enhances innovation activities.
2. Individual and collaborative capabilities to identify problems/issues/needs.
3. Translate broadly defined opportunities into actionable innovation possibilities.

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Define design thinking mindset	1	-	-
CO-2	Build empathy for target audiences from different cultures.	-	2	-
CO-3	Utilize the design thinking resources	3	-	-
CO-4	Develop a strong understanding of the design process and its application in business settings.	1,2	-	4
CO-5	Apply design thinking tools and methods for product development	1	2	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	3	2.3	3	1	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil.

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Course Contents:

Unit - I

Design Thinking Background: Definition of Design Thinking, Business uses of Design Thinking, Variety within the Design Thinking Discipline, Design Thinking Mindset.

Self-study: Morphology of design, design methods - morphological analysis, AIDA, brainstorming, lateral thinking and puzzles on lateral thinking, creativity, design optimization. **7 Hrs**

Unit – II

Design Thinking Approach: Fundamental Concepts, Empathy, Ethnography, Divergent Thinking, Convergent Thinking, Visual Thinking, Assumption Testing, Prototyping, Time for Learning and Validation.

Design Thinking Resources: People, Place, Materials, Organizational Fit. **8 Hrs**

Unit – III

Design Thinking Processes: Numerous Approaches, Double Diamond Process, 5 Staged. School Process, Designing for Growth Process, Role of Project Management. **8 Hrs**

Unit – IV

Design Thinking in Practice: Process Stages of Designing for Growth, What Is, What If, What Wows, What Works.

Design Thinking Application: Design Thinking Applied to Product Development. **8 Hrs**

Unit – V

Design Thinking Tools and Methods: Purposeful Use of Tools and Alignment with Process, What Is: Visualization, What Is: Journey Mapping, What Is: Value Chain Analysis, What Is: Mind Mapping, What If: Brainstorming, What If: Concept Development, What Wows: Assumption Testing, What Wows: Rapid Prototyping, What Works: Customer Co-Creation, What Works: Learning Launch**.** **8 Hrs**

Text Book:

1) A4Q - Alliance for Qualification Design Thinking booklet, 2018

Reference Books:

1) Jeanne Liedtka and TimOgilvie, “Designing for growth - A design thinking tool kit for managers”, 2011.
2) MichaelLewrick, Patrick Link, LarryLeifer, “The design thinking play book: Mindful digital transformation of teams, products, services, businesses and ecosystems”, 2018.

3) Leo Frishberg and Charles Lambdin, “Presumptive design: Design provocations for innovation”, 2016.
4) Jamshid Gharajedaghi, “Systems thinking: Managing chaos and complexity: A platform for designing business architecture, Chapter Seven: Design Thinking”, 2011.

18UMEO646	Smart Materials and Structures	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Concept of smart materials and its application
2. Modeling concept in smart materials
3. Fibre optics, piezoelectric sensing and actuation.

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO1	Explain basic concepts of smart materials, structures and their characteristics.	1	2	-
CO2	Model smart materials for various applications.	1	2	-
CO3	Analyze the properties of smart structures.	1	-	2
CO4	Describe various fiber optics sensors and their applications.	1	2	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	3	1.8	-	-	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit - I

Introduction: Introduction of Smart Materials, Piezoelectric Material, Magnetostrictive smart Material, Active Smart Polymer, Shape Memory Alloys, Applications of Smart Material, difference between traditional structure and smart structure. **9 Hrs**

Unit - II

Shape Memory Alloys: Introduction, Phenomenology, and Influence of stress on characteristic temperatures, modelling of shape memory effect. Vibration control through shape memory alloys. **8 Hrs**

Unit - III

Electro rheological and Magneto rheological Fluids: Mechanisms and Properties, Characteristics, Fluid composition and behavior, Discovery and Early developments, Summary of material properties. Applications of ER and MR fluids (Clutches, Dampers, others). **8 Hrs**

Unit - IV

Modelling: Piezoelectric material, modelling of Magnetostrictive material, Modelling of Shape memory Alloys, Smart Actuators, Smart Materials based MEMS, Energy Harvesting, and Concept of Self-Healing. **6 Hrs**

Unit - V

Fibreoptics: Introduction, Physical Phenomenon, Characteristics, Fibre optic strain sensors, Twisted and Braided Fibre Optic sensors, Optical fibres as load bearing elements, Crack detection applications, Integration of Fibre optic sensors and shape memory elements. **8 Hrs**

Text Book:

1) M.V.Gandhi and B.S.Thompson “Smart Materials and Structures”, Chapmen & Hall, London, 1992.

Reference Books:

2) A. V. Srinivasan, D. Michael McFarland “Smart Structures - Analysis and Design”, Cambridge University Press, New York, 2000.
3) Gauenzi, P, “Smart Structures”, Wiley, 2009.
4) Cady, W. G, “Piezoelectricity”, Dover Publication 1950 Publication, 1950.
5) Crawley, E. F, “Intelligent Structures for Aerospace: a technology overview and assessment”, AIAA, 33 (8), 1994, pp. 1689 assessment, AIAA, 33 (8), 1994.

18UMEO647 Introduction to Scientific programming (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. To improve their ability in solving mathematical problems using Python software
2. To develop skills in handling errors, functions and loops in program, enhance problems solving capability.
3. To emphasize signification of plotting graphs and interpreting the data's in Python software.
4. To gain knowledge in scientific methods and familiarize with application of differential equation and integration to solve engineering problems.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1,12) / PSO (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Develop program by analyzing problem and handling errors in Python software.	5	1,2	3
CO-2	Use data structures in programming approach.	5	1,2	3
CO-3	Apply function features to develop realistic programs.	5	1,2	3
CO-4	Develop Python Programs using NumPy array and matplotlib for solving problems	5	1,2	3
CO-5	Use various package's and libraries SciPy, ODEINT to solve a mathematical problem.	5	1,2	3

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2	2	1	-	3	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Course Contents:

Unit - I

Introduction: Introduction to Python, Installing Python, Tools for Writing Programs, Using Idle to Write the Program, How to Run the Program, variables, expressions and statements, Reserved Words in Python, Evaluating Standard Mathematical Functions, Interactive Computing, Exercises. **7 Hrs**

Unit - II

Loops and Lists: While Loops, Lists, Getting Individual Values in a List with Indexes, Negative Indexes, Getting Sublists with Slices, Getting a List's Length with len(), Changing Values in a List with Indexes Implementations with Lists and Loops, Tuples. **8 Hrs**

Unit - III

Functions: Basics of functions, Functions of One Variable, Local and Global Variables, Multiple Arguments, Function Input and Output, Functions as Arguments to Functions, Lambda Functions, Exercises. **8 Hrs**

Unit - IV

Array Computing and Curve Plotting: Basic array methods, Reading and writing an array to a file, Polynomials, Linear algebra, Matrices, computation with matrix, dot product, cross product, inverse matrix.

Matplotlib: Introduction, Matplotlib basics, Contour plots, 3D plots. **8 Hrs**

Unit - V

Differential Equations and Integration: The Simplest Case, ordinary differential equation and partial differential equation, Integration and double integration, initial value problems, optimization. **8 Hrs**

Activity Beyond Syllabus: working with simple real-time application in Python software.

Text Books:

1) Allen B. Downey, "Think Python", Second Edition, O'Reilly Publication, 2015.
2) Christian Hill, "Learning Scientific Programming with Python", Cambridge University Press, 2015.

Reference Books:

1) Charles Dierbach, "Introduction to Computer Science Using Python", 1st Edition, Wiley India Pvt Ltd, 2015.
2) T.R. Padmanabhan, "Programming with Python", Springer, 2016.
3) Hans Petter Langtangen, "A Primer on Scientific Programming with Python", Springer; 3rd ed, 2012.

18UMEE723 Hybrid Vehicle Technology (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2. Explain plug – in hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.
3. Analyze various electric drives suitable for hybrid electric vehicles.
4. Discuss different energy storage technologies used for hybrid electric vehicles and their control.
5. Demonstrate different configurations of electric vehicles and its components, hybrid vehicle configuration by different techniques, sizing of components and design optimization and energy management

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain working of IC engines and factors affecting the combustion	-	1	-
CO-2	Discuss different configurations of electric and hybrid vehicles and their parts.	-	1,2	-
CO-3	Describe various aspects of hybrid and electric vehicle drive trains	-	1,2	3
CO-4	Discuss different energy storage technologies and control	-	1,2	-
CO-5	Explain sizing of drive system, components, and pollution aspects	-	2,6, 7	3

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	3	2	1	-	-	2	1	-	-	-	-	-	-	-

Prerequisites: Nil

Contents:

Unit - I

Conventional Vehicles: Introduction to conventional internal combustion engines, Basics of vehicle performance, vehicle power source, Power

transmission, Fuel economy characteristics of internal combustion engine.

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, Merits and demerits of electric and hybrid vehicles. **8 Hrs**

Unit - II

Basic concept of Electrical and Hybrid vehicles: Hybrid traction, introduction to various hybrid drive-train topologies, Vehicle power plant and transmission characteristics and vehicle performance including braking performance. Basic architecture of hybrid drive train and analysis series drive train. Analysis of parallel, series parallel and complex drive trains and power flow in each case. Basic concept of electric traction and architecture. Topologies for electric drive-train and their analysis, power flow control in electric drive-train topologies. **8 Hrs**

Unit - III

Electric Propulsion Systems: Components used in hybrid and electric vehicles, Electric drives used in HEV/EVs, their classifications and general characteristics. Induction motors, their configurations and optimization for HEV/EVs. Induction motor drives, their control and applications in EV/HEVs. DC Motor drives and their principle of operation and performance including multi-quadrant control. Permanent magnet motors, their configurations and optimization. Permanent magnet motor drives, their control and applications in EV/HEVs. Configuration and control of DC and Induction Motor drives.
8 Hrs

Unit - IV

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis and simplified models of battery. Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices. **7 Hrs**

Unit - V

Sizing the drive system: Matching the electric drive and ICE, Transmission selection and gear step selection. Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology.
Air pollution and global warming: Impact of different transportation technologies on environment and energy supply. **8 Hrs**

Reference Books:

1) James Larminie, John Lowry, “Electric Vehicle Technology Explained”, Wiley, 2003.

2) Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2004.
3) Iqbal Hussein, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, 2003.
4) R1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals”, CRC Press, 2010.
5) Sandeep Dhameja, “Electric Vehicle Battery Systems”, Newnes, 2000.
6) John B Heywood, “IC Engine Fundamentals”, International Editions, Automobile Technology Series, McGraw hill, 2010.
7) M. L. Mathur and R. P. Sharma, “I.C. Engines”, Dhanpat Rai & Sons, New Delhi, 2011.

18UMEE725	Advanced Heat Transfer	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objective of this course is to make the student aware of:

6. Heat transfer concepts for finned systems,
7. Heat transfer concepts for turbulence flows, and high-speed flows.
8. Thermal analysis and sizing of heat exchangers and to learn the heat transfer coefficient for compact heat exchanges.
9. The numerical techniques to handle heat transfer problems

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1-4)		
		Substantial Level(3)	Moderate Level(2)	Slight Level(1)
CO-1	Summarize physics and mathematical treatment of advanced topics of heat transfer.	-	1	2
CO-2	Apply principles of heat transfer to develop mathematical models for fins.	-	1,2,3	--
CO-3	Solve 2D and 3D heat conduction problems using mathematical functions and charts.	-	1, 2, 3	--
CO-4	Solve free and forced convection problems with proper boundary conditions.	-	1,2	-
CO-5	Use the concepts of radiation heat transfer for enclosure analysis.	-	1,2	

POs/PSOs	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mapping Level	2	1.8	2	-	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Content:

Unit - I

Introduction and one-dimensional heat transfer: The differential equation of heat conduction, heat generation, two dimensional steady state heat conduction, unsteady state processes, extended surfaces- fins of uniform cross section and non-uniform cross sections, Thermal resistance networks and applications. Numerical heat Transfer: Numerical techniques for solving heat conduction problems, the finite difference method for steady state situations, the finite difference method for unsteady state situations, Controlling Numerical Errors, problems. **9 Hrs**

Unit - II

Thermal radiation: Basic concepts and laws of thermal radiation, the shape factor, Eradiant heat exchange in enclosures ,black and Grey surfaces ,radiation shields and Radiation Effect on temperature measurements. Radiation properties of participating Medium, Emissivity and absorbivity of Gases and Gas Mixtures, Heat transfer from the Human Body problems. **6 Hrs**

Unit - III

Analysis of Convection Heat Transfer: Boundary layer fundamentals evaluation of convection heat transfer coefficient, Analytical solution for laminar boundary layer flow over a flat plate ,Approximate integral boundary layer analysis, Analogy between momentum and heat transfer in turbulent flow over a flat surface, Reynolds Analogy for Turbulent Flow Over Plane Surfaces, Mixed Boundary Layer, Special Boundary Conditions and High-Speed Flow. **8 Hrs**

Unit - IV

Natural convection: Introduction, Similarity Parameters for Natural Convection, Empirical Correlation for Various Shapes, Rotating Cylinders, Disks, and Spheres, Finned Surfaces. Heat transfer by forced convection: Introduction, Analysis of Laminar Forced Convection in a Long Tube, Correlations for Laminar Forced Convection, Analogy Between Heat and Momentum Transfer in Turbulent Flow, Empirical Correlations for Turbulent Forced Convection, Heat Transfer Enhancement and Electronic-Device Cooling, Flow Over Bluff Bodies , Packed Beds, Free Jets. **9 Hrs**

Unit - V

Heat exchangers: Basic concepts, types of heat exchangers, Analysis of heat exchangers, Counter-Flow Heat Exchangers, Multipass and Cross-Flow Heat Exchangers, Use of a Correction Factor , Selection of Heat Exchangers such as Heat Transfer Rate ,Cost ,Pumping Power, Size and Weight ,Type, Materials, Other Considerations, Compact Heat Exchangers. Heat Exchangers for multi phaseflow. **7 Hrs**

Reference Books:

1) Ozisik M.N., “Heat Transfer – A Basic Approach”, 1st edition, McGraw-Hill Publications, 1985
2) Holmon J. P, “Heat Transfer “, McGraw-Hill Publications, 6th Edition.
3) Frank Kreith, “Principles of Heat Transfer”, 7th Edition.Thomson Publications,
4) Yunus A Cengel, “Heat Transfer- A practical Aproach”, 2nd edition, McGraw-Hill Publications.2002.

18UMEE726 Heating ventilation and air conditioning (HVAC) (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. The thermodynamic cycle employed in of air-conditioning
2. Properties of air and ventilation in building and its significance
3. The types and working of air-conditioning systems
4. Heating and cooling load calculation for thermal comfort in building
5. Fluid flow and duct design for air conditioning system

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Review the thermodynamics of vapor compression cycle	-	1,2	-
CO-2	Calculate properties of air through equations and psychrometric chart	1,2	-	-

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CO-3	Explain heating, and ventilation of different air conditioning systems	1,2	-	-
CO-4	Determine cooling load on the air conditioning system	-	1,3	-
CO-5	Calculate insulation thickness, duct size and list the noise control strategies for A/C systems	-	1,2	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.4	2.4	2	-	-	-	-	-	-	-	-	-	-	-

Pre-requisites: Nil

Contents:

Unit - I

Introduction: Review of vapor compression refrigeration cycles, T-S and PH charts, refrigerants, and components

Psychrometry: Properties and relations Psychrometric processes Winter air conditioning system and summer air conditioning system and year around air condition system psychrometric chart. **8 Hrs**

Unit - II

Ventilation and infiltration factors affecting thermal comfort, comfort charts, indoor air quality, outdoor design conditions, natural and mechanical ventilation, air distribution devices.

Heating systems: Warm air, hot water and steam heating systems, panel and infrared heating system. **8 Hrs**

Unit - III

Cooling load calculation for design of air conditioning systems heat sources, heat loads in building, design of air conditioning systems, bypass factor effective sensible heat factor cooling coils and dehumidifying air washers and numericals **8 Hrs**

Unit - IV

Air conditioning systems: Central, Unitary and district air conditioning systems, all water, all air, air-water systems factory air conditioning

Insulation for air conditioning systems: desired properties, factors and types of insulating materials. Heat transfer through insulation, economical thickness, selection of insulating material **8 Hrs**

Unit - V

Fluid flow and duct design for air conditioning systems: Pressure loss duct sections, distribution and design, air distribution and ventilation systems, temperature gradients Noise control in air conditioning systems. **7 Hrs**

Reference Books:

1) Arora and domkundwar, dhanpat rai and sons, “A course on Refrigeration and air conditioning”, 2018.
2) Manohar Prasad, “Refrigeration and air conditioning”, Newage international (P) Limited, publishers 2006.
3) Kreider, Peter S Curtiss, “Heating and cooling of building”, principals and practice of energy efficient design, Jan F CRC Press 2018.
4) ASHRAE hand book (HVAC systems)
5) Stocker W.F and Jones J W. “Refrigeration and air conditioning”, Mc Graw hill 1982.
6) ASHRAE, “Air conditioning System Design manual”, 2nd Edition

18UMEE727	Battery and Fuel Cell Technology	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

5. Significance of fuel cells in present energy context of India
6. Working of different batteries
7. Working of different fuel cell and thermodynamics
8. Hydrogen production and storage methods

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain energy scenario and fuel cells as future source of power	-	1	7
CO-2	Describe the working of primary and secondary types of batteries	-	1, 2	6
CO-3	Explain the working principles of fuel cells.	-	1	7
CO-4	Evaluate efficiency and thermodynamic parameters related to fuel cells.	1	2	7
CO-5	Describe different methods of production and storage of hydrogen for fuel cells.	-	1	6, 7

POs/PSOs	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mapping Level	2.2	2	-	-	-	1	1	-	-	-	-	-	-	-

Prerequisites: Nil

Contents:

Unit - I

Indian energy scenario , sector wise energy patterns, need for alternate sources of energy, fuel cell as an alternate sources of energy pros and cons, brief historical background of fuel cells and batteries , basic working principle and comparison of fuel cell and batteries , international and national status of fuel cell development and application. Fuels for Fuel Cells: Hydrogen, methane, methanol - Sources and preparation, reformation processes for hydrogen. **6 Hrs**

Unit - II

Batteries: Introduction, working of primary and secondary batteries: The chemistry, fabrication, and performance aspects, packing classification and rating of the following batteries: Zinc-carbon, zinc alkaline zinc/air batteries; Lithium primary cells - liquid cathode, solid cathode and lithium-ferrous sulphide cells

Secondary batteries: Lead acid, nickel-cadmium, nickel-zinc, nickel-metal hydride batteries, lithium-ion batteries, ultrathin lithium polymer cells. Advanced Batteries for electric vehicles, requirements of the battery, depth of discharge, sodium-beta and redox batteries. **8 Hrs**

Unit - III

Fuel Cells: Description, working principle, anodic, cathodic and cell reactions, fabrication of electrodes and other components, applications, advantages, disadvantages and environmental aspects of the following types of fuel cells: Proton Exchange Membrane Fuel Cells, alkaline fuel cells, phosphoric acid, solid oxide, molten carbonate, direct methanol fuel cells.

Membranes for fuel cells: Nafion – Polymer blends and composite membranes; assessment of performance – recent developments. **9 Hrs**

Unit - IV

Thermodynamics of fuel cells: First law second law, heat potential reaction enthalpies, Gibbes free energy , reversible voltages, fuel cell efficiency, Nernst equation analysis effect of temperature and pressure and concentration, concept of electrochemical potential calculation of standard electrode potential **9 Hrs**

Unit - V

Hydrogen production and storage: Advantages and disadvantages of using hydrogen as fuel, hydrogen production methods, hydrogen storage, recent

developments in storage and production of hydrogen. **7 Hrs**

Reference Books:

1) M. Aulice Scibioh and B. Viswanathan “Fuel Cells – principles and applications”, University Press, India, 2006.
2) F. Barbir, “PEM fuel cells: theory and practice”, Elsevier, Burlington, MA, 2005.
3) Dell, Ronald M Rand, David A J, “Understanding Batteries”, Royal Society of Chemistry, 2001.
4) G. Hoogers, “Fuel cell handbook”, CRC, Boca Raton, FL, 2003.
5) Ryan P. O'Hayre, Suk-Won Cha, Whitney Colella and Fritz B. Prinz, Fuel cell fundamentals, John Wiley and Sons, 2006

18UMEO734 Design of Renewable Energy Systems (3-0-0) 3

Contact Hours: 39

Course Objectives (CLO’s): The objectives of this course are to make the student to learn:

1. Energy sources and need of alternative resources.
2. Principles for design and analysis of Renewable Energy Systems
3. Economics & Environmental of energy conversion in renewable energy systems
4. Renewable energy systems for sustainability

Course Outcomes (CO’s):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Review the need of renewable energy sources for energy requirement	-	1	2
CO-2	Analyze the renewable energy source conversion to different forms of energy	-	2,3	-
CO-3	Design different renewable source for small to large scale applications	-	2,3	7
CO-4	Illustrate the economic viability and sustainability of renewable energy systems	-	-	1,14
CO-5	Compare different renewable energy systems based on techno-economic feasibility	-	2	7,14

POs/PSOs	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mapping Level	1.5	1.7	2	-	-	-	1	-	-	-	-	-	-	1

Pre requisites: Nil

Contents:

Unit - I

Renewable Energy sources: Introduction, Factors affecting the use of renewable energy sources, Global warming and sustainable development. Renewable energy resources, type's brief energy conversion methods and use pattern of Renewable energy sources in present context in India.

Solar thermal energy systems: Introduction to solar energy, solar radiation data, methods of conversion, different conversion devices Flat plate collectors, concentrating collectors. Principle of design for thermal and other forms of conversion. Principal of solar thermal devices. **8 Hrs**

Unit - II

Solar Direct and Indirect conversion: Direct conversion of solar energy to electrical energy, Performance evaluation of PV cell, modules, Panels and arrays and optimization. Principal of conversion solar energy to electrical by using heat engines.

Wind energy systems (WES): Characteristics of wind, wind power profile, aerodynamics of wind turbines. Basic elements of WES, Siting and sizing of WES, Wind turbine site matching, Applications. **9 Hrs**

Unit - III

Biomass energy systems: Densification, Biomass combustion technology, Thermo-chemical and biochemical conversion to useful energy conversion such as thermal, electrical and mechanical energy. Material, size and types of biogas plants.Bio-fuels importance & production. Principal components of Engine Biomass systems.

Other renewable energy systems & hybridization: Wave, Tidal, OTEC, Geothermal, And Hydrogen: Principal of conversion and its utilization individually and in hybrid form. **9 Hrs**

Unit - IV

Economic and environmental aspects of renewable systems: Economic analysis of renewable sources. Based on the life cycle pollution aspect of renewable systems. **7 Hrs**

Unit - V

Solar thermal energy systems: Wind energy systems (WES): Biomass energy systems design analysis including economic aspects of the renewable systems. Energy, exergy analysis of above systems. **6 Hrs**

Text Books:

1) G. D. Rai, “Non-Conventional Energy Sources”, Khanna Publishers, New Delhi, Dec 2004.
2) S. Rao, Dr. B. B. Parulekar, “Energy Technology”, 3rd edition, Khanna Publishers, Delhi, 2007.

Reference Books:

1) Ziyad Salameh, “Renewable Energy System Design”, Academic Press, ELISIEVIR.2014.
2) S. P. Sukatme, “Solar Energy”, TATA McGraw Hill, 1996.
3) Kreith & Goswami, “Solar Energy”, Taylor & Francis 1999.

18UMEE822	Computer Integrated Manufacturing	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Basics of Computer Integrated Manufacturing.
2. Automated assembly system.
3. Latest computerized manufacturing practices.
4. Shop floor control & quality.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain the basic concepts of automation, flow lines, line balancing and high-volume production systems.	-	1, 2	-
CO-2	Analyze different Automated Flow Line, and line balancing.	1	2	-
CO-3	Analyze different Automated Assembly systems. Describe Material handling system, Automated guided vehicle system.	1	2	-
CO-4	Describe Computerized Manufacturing & Planning Systems and basics of Robotics in industry.	-	1, 2	-
CO-5	Describe shop floor control systems and computer aided quality control systems in a factory environment.	-	1, 2	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.4	2	-	-	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil.

Contents:

Unit - I

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Computer Integrated Manufacturing System: Introduction, Types of Automation, Production concepts, Mathematical Models, Automation Strategies (Numerical).
High Volume Production System: Automated FLOW lines, Work Part Transport Mechanism, Buffer Storage (Numerical). **8 Hrs**

Unit - II

Analysis of Automated Flow Line and line balancing: Analysis of Transfer Lines without storage and with storage, Partial automation, Manual Assembly Lines, Methods of line balancing, Computerized line balancing (Numerical) **8 Hrs**

Unit - III

Automated Assembly System: Types, Parts feeding Devices, Analysis of single station assembly machine, Analysis of multi station assembly machine, automated material handling system, Automated guided vehicle system. **8 Hrs**

Unit - IV

Computerized Manufacturing Planning System: Computer Aided Process Planning: Retrieval Type, Generative type. Material Requirement Planning, Fundamental concepts of MRP, Inputs to MRP, Capacitive Planning.
Robotics: Introduction to Robot, Robot anatomy and configuration, work volume, end effectors, Robot sensors and Robot applications. **8 Hrs**

Unit - V

Shop Floor Control: Factory Data Collection System, Automatic Identification System.
Computer Aided Quality Control: Contact inspection methods, Non-contact inspection methods, Co-ordinate Measuring Machine. **7 Hrs**

Text Book:

1) Mikell O. Groover, “Automation, Production system and Computer Integrated Manufacturing”, 3rd edition, PHI, New Delhi, 2010.

Reference Books:

1) Mikell P. Groover, “CAD/CAM”, 3rd edition PHI, New Delhi, 2003.
2) Ibrahim Zeid, “CAD/CAM”, 2nd edition, Tata McGraw Hill, 2010.

18UMEE825	Rapid Prototyping and Rapid Tooling	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. The basics of rapid prototyping techniques for processing of CAD models.
2. Apply fundamentals of rapid prototyping techniques and concept modellers.
3. To distinguish appropriate software for rapid prototyping processes.
4. To recognize rapid prototyping and rapid tooling techniques for different tooling industries.

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain the basic concepts, and classifications of prototyping in current product design scenario.	-	1, 2, 5	-
CO-2	Describe Stereo Lithography and Selective Laser Sintering processes.	1	5	-
CO-3	Discuss FDM, SGC and LOM RP processes, and functionality of Concept Modellers.	1	5	-
CO-4	Describe various Rapid Tooling systems in industrial sectors.	1	5	-
CO-5	Explain the different process optimizing techniques and software tools in Rapid Prototyping	-	1, 5	

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.6	2	-	-	2	-	-	-	-	-	-	-	-	-

Pre requisites: Nil.

Contents:

Unit - I

Introduction: Introduction to Prototyping, Traditional Prototyping Vs. Rapid Prototyping (RP), Classification of Rapid Manufacturing Processes: Additive, Subtractive, Formative, Generic RP process. Need for the compression in product development, history of RP systems, Survey of applications, Growth of RP industry, and classification of RP systems.**6 Hrs**

Unit - II

Stereo Lithography Systems: Principle, Process parameter, Process details, Data preparation, data files and machine details, Application.

Selective Laser Sintering: Type of machine, Principle of operation, process parameters, Data preparation for SLS, Applications. **7 Hrs**

Unit - III

Fusion Deposition Modelling: Principle, Process parameter, Path generation, Applications.

Solid Ground Curing: Principle of operation, Machine details, Applications.

Laminated Object Manufacturing: Principle of operation, LOM materials. Process details, application.

Concept Modellers: Principle, Thermal jet printer, Sander's model market, 3-D printer. GenisysXs printer HP system 5, object Quadra systems.**10 Hrs**

Unit - IV

Rapid Tooling: Indirect Rapid tooling: Silicon rubber tooling, Aluminium filled epoxy tooling, Spray metal tooling.

Direct rapid tooling: Quick cast process, copper Polyamide, DMILS explanation, Prometals, sand casting tooling, Laminate tooling, Soft tooling & hard tooling. **8 Hrs**

Unit - V

Software for RP: STL files, Overview of Solid view, magics, imics, magic communicator, etc. Internet based software, Collaboration tools.

Rapid Manufacturing Process Optimization: factors influencing accuracy. Data preparation errors, Part building errors, Error in finishing, influence of build orientation. **8 Hrs**

Reference Books:

1) Chua C K, Leong K F, Chu S L, “Rapid Prototyping”, Principles and Applications in Manufacturing, World Scientific.
2) Gibson D W Rosen, Brent Stucker, “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer.
3) Noorani R, “Rapid Prototyping: Principles and Applications in Manufacturing”, John Wiley & Sons.
4) Hilton P, Jacobs P F, “Rapid Tooling: Technologies and Industrial Applications”, CRC press.
5) Liou W L, Liou F W, “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press.
6) Kamrani A K, Nasr E A, “Rapid Prototyping: Theory and practice”, Springer

18UMEE826	Design For Manufacturing And Assembly	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. To identify major phases of design, effect of material properties on design, material selection process, tolerance analysis, review of tolerance grades through different manufacturing processes.
2. Identifying and analyzing various interchangeable part assembly, group tolerance, and functional datum.
3. Reviewing design considerations in casting, special sand cores, component design, component milling, drilling and finished machining.
4. Identifying and discriminating conventional feature location, tolerance, virtual size concept, position tolerance, functional gauge.

5. Identifying the importance of design of gauges for components checking in assembly.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify effect of material properties on design, and explain tolerance analysis	1,2	-	3
CO-2	Discuss various interchangeable part assemblies, group tolerance, and functional datum.	1	-	3
CO-3	Review design considerations in various manufacturing processes.	-	1,2	-
CO-4	Explain component design for various machining processes.	-	1, 2	-
CO-5	Explain various tolerancing methods and gauge design.	-	1, 2	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.4	2.7	1	-	-	-	-	-	-	-	-	-	-	-

Content:

Unit - I

Effect of Materials And Manufacturing Process On Design: Major phases of design. Effect of material properties on design Effect of manufacturing processes on design. Material selection process- cost per unit property, Weighted properties and limits on properties methods.
Tolerance Analysis: Process capability, mean, varience, skewness, kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances, Geometries tolerances, Geometric tolerances, Surface finish, Review of relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerance – Sure fit law and truncated normal law. **8 Hrs**

Unit - II

Selective Assembly: Interchangeable part manufacture and selective assembly, Deciding the number of groups -Model-1: Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control

of axial play-Introducing secondary machining operations, laminated shims, examples.

Datum Features: Functional datum, Datum for manufacturing, changing the datum. Examples. **7 Hrs**

Unit - III

Design Considerations: Design of components with casting consideration. Pattern, Mould, and Parting line. Cored holes and machined holes. Identifying the possible and probable parting line. Casting requiring special sand cores. Designing to obviates and cores. **10 Hrs**

Unit - IV

Component Design: Component design with machining considerations link design for turning components-milling, Drilling and other related processes including finish- machining operations. **6 Hrs**

Unit - V

True positional theory: Comparison between coordinate and convention method of feature location. Tolerance and true position tolerancing virtual size concept, Floating and fixed fasteners. Projected tolerance zone. Assembly with gasket, zero position tolerance. Functional gauges, Paper layout gauging.

Design of Gauges: Design of gauges for checking components in assemble with emphasis on various types of limit gauges for both hole and shaft.

8 Hrs

Reference Books:

1) Harry Peck, “Designing for Manufacturing”, Pitman Publications, 1983.
2) Dieter, “Machine Design”, McGraw-Hill Higher Education, -2008
3) R. K. Jain, "Engineering Metrology", Khanna Publishers, 1986
4) Geoffrey Boothroyd “Product design for manufacture and assembly”, 3rd Edition, Peterdewhurst, Winston Knight, Merceldekker. Inc. CRC Press,
5) “Material selection and Design” Vol. 20 - ASM Hand book.

18UMEE827	Estimation and Costing in Mechanical Engineering	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. The estimation and costing procedure in industries.
2. The actual costing process and calculation of selling prices.
3. The depreciation of equipment, plants and to know the different methods of calculating depreciation.
4. The procedure for calculating material cost of various components.
5. The procedure for estimation of various shop, labour wages and incentives.

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain the estimation and costing procedure in industries.	-	1,2,11, 14	9,12
CO-2	Calculate the actual cost and selling prices.	14	1,2,6,11	9,12

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CO-3	Estimate the depreciation of equipments, plants and machineries.	14	1,2,6,11	9,12
CO-4	Estimate material cost of various components	14	1,2,6,11	9,12
CO-5	Calculate various costs of various shops, labour wages and incentives	14	1,2,6,11	9,12

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2	2	-	-	-	2	-	-	1	-	2	1	-	2.8

Pre requisites: Nil.

Contents:

Unit - I

Introduction to Estimation and costing: Estimation - Definition, Importance and Aims, Qualities and functions of an Estimator, Source of errors in estimation, Constituents of Estimation, Costing - Definition and Aims, Standard cost and its Advantages, Difference between estimation and costing, Advantages of efficient costing

Elements of costs: Elements of cost- material, labour, expenses, Material - Direct material, indirect material and examples, Calculation of Material cost, Labour - direct, indirect labour and examples. Calculation of labour cost, Expenses - direct, indirect expenses and examples, Classification of expenses - factory, administrative, selling and distribution expenses and examples, Fixed and variable expenses and examples, Components of cost - prime cost, factory cost, office cost, total cost, Selling price, Block diagram to show the relationship between elements and components of cost, problems on above, Allocation of on-cost - methods and simple problems **8 Hrs**

Unit – II

Indirect expenses and depreciation: Indirect expenses - depreciation, obsolescence, inadequacy, idleness, repair and maintenance, Depreciation - causes, methods of calculating depreciation, Simple problems on each method

Mensuration and Estimation of material cost: Area of regular plane figures, Volume and surface area of solids (formulae only), Estimation of material costs of step pulley, spindle lathe centre, Rivets, Fly wheel, Crankshaft, Chain link, Wedge and Gib-headed key. **8 Hrs**

Unit - III

Mechanical Estimation: Estimation in machine shop - Definition of cutting speed, feed, depth of cut, Estimation of time for various operations like Turning, Knurling, Facing, Drilling, Boring, Reaming, Threading, Tapping, Milling, Grinding, Shaping and Planning, Estimation in sheet metal shop -

Sheet material and gauge number, Sheet metal joints, Select suitable formula for estimation, Estimate the material required for preparation of container open on one side Cylindrical drum, funnel and tray, Estimation in foundry shop-pattern allowances, estimation of pattern cost, simple problems on C.I pulley and C.I. Wheel, Estimation in welding shop - estimation of gas welding cost, estimation of arc welding cost -Simple problems **10 Hrs**

Unit - IV

Wages and incentives: Definition of wages, normal wages, real wages, living wages, fair wages minimum wages, methods of wage payment, Incentives - definition of incentive, types of incentives, examples, Characteristics of a good wage and incentive systems, Standard time - work measurement, Bonus system - collective bonus system, group bonus system. **6 Hrs**

Unit - V

Project planning and Break even analysis: Concept of project work, Project planning like market survey, project capacity, selection of site, plant layout, product design, drawing, specification, material requirement operation planning, Break even analysis - break event chart, diagram to illustrate break event point, Simple problems on break even analysis. **7 Hrs**

Reference Books:

1) T. R. Banga and S. C. Sharma “Mechanical estimation and costing”, Khanna Publishers,
2) Acharya and Narang “Estimation and costing”,
3) Banga and Sharma, “Industrial Organisation and Engineering Economics”,
4) Malhotra, “Mechanical Estimation”,

18UMEE832	Mechanics of Composite Materials	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

4. Various properties of composite materials.
5. To determine the generalized stiffness and compliance matrix relating in plane stresses to strains for a composite layer assuming plane stiffness.
6. Manufacturing and testing methods of composites.

Course Outcomes (COs):

Description of the course outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain various aspects of composite materials.	-	1,2	-
CO-2	Apply the generalized Hooks law for macro mechanics of lamina.	1	2	3
CO-3	Discuss various failure criteria and evaluate parameters related to micro mechanics of lamina.	-	1	2
CO-4	Describe various composite manufacturing methods.	-	1, 2	-
CO-5	Discuss non-destructive testing methods and applications of composites.	-	1	2

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POs/PSOs	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mapping Level	2.2	1.6	1	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Nil.

Content:

Unit - I

Introduction to Composite Materials: Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction. Metal Matrix Composites: Reinforcement materials, Types, Characteristics and selection, Applications. **6 Hrs**

Unit - II

Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems. **9 Hrs**

Unit - III

Micro Mechanical Analysis of a Lamina: Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems. Experimental Characterization of Lamina- Elastic Moduli and Strengths. Failure Criteria: Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsai-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations. **9 Hrs**

Unit - IV

Manufacturing: Layup and curing - open and closed mould processing, Hand lay-up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair. **8 Hrs**

Unit - V

Non-Destructive testing: Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.

Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites. **7 Hrs**

Reference Books:

12. AUTAR K.KAW, “Mechanics of composite materials”, Taylor and Francis group.
13. Rober M. Jones, “Mechanics of Composite Materials”, Taylor & Francis, 1998.

18UMEE833 Modeling and Simulation of Dynamic Systems (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Basic concepts related to modeling and simulation
2. Bond graph according to causality conflicts, and from a given bond graph
3. Find dynamic response and transfer function using various tools for system modeling.
4. Modeling and simulation of mechanical and electrical systems using computer tools

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain basic concepts related to modeling and simulation	-	1,2	-
CO-2	Analyze the bond graph according to causality conflicts, and from a given bond graph	1,2	-	-
CO-3	Use conservation laws and constitutive relationships to model mechanical, electrical and flow systems, and combinations of these.	-	1,2	-
CO-4	Find dynamic response and transfer function using various tools for system modeling.	-	1,2	-
CO-5	Model and simulate mechanical and electrical systems using softwares	1,2	-	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.4	2.4	-	-	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Contents:

Unit - I

Introduction to modeling and simulation: Introduction to modeling, Examples of models, modeling of dynamic system, Introduction to simulation, MATLAB as a simulation tool, Bond graph modeling, causality, generation of system equations. **8 Hrs**

Unit - II

Random-Number Generation, Random-Variate Generation: Properties of random numbers; Generation of pseudo-random numbers; Techniques for generating random numbers; Tests for Random Numbers Random-Variate Generation: Inverse transform technique; Acceptance Rejection technique; Special properties. **7 Hrs**

Unit - III

Input Modeling: Data Collection; Identifying the distribution with data; Parameter estimation; Goodness of Fit Tests; Fitting a non-stationary Poisson process; Selecting input models without data; Multivariate and Time-Series input models.

System models of combined systems: Linearity and non linearity in systems combined rotary and translatory system, electro mechanical system, hydromechanical system. **8 Hrs**

Unit - IV

Dynamic Response and System Transfer Function: Dynamic response of 1st order system and 2nd order system, performance measures for 2nd order system, system transfer function, transfer function of 1st and 2nd order system Block diagram algebra, signal flow diagram, state variable formulation, frequency response and bode plots. **8 Hrs**

Unit - V

Types of simulations with respect to output analysis: Stochastic nature of output data; Absolute measures of performance and their estimation; Output analysis for terminating simulations; Output analysis for steady-state simulations.

Verification, Calibration, and Validation; Optimization: Model building, verification and validation; Verification of simulation models; Calibration and validation of models, optimization via Simulation **8 Hrs**

Reference Books:

1) Gordon, G., “System Simulation”, 2nd edition, Prentice-Hall 1978.
2) Close, C.M., and Frederick, D.K., “Modeling and Analysis of Dynamic Systems”, 2nd edition, John Wiley & Sons 1995.
3) Bhonsle, S. R., and Weinmann, K. J., “Mathematical Modeling for Design of Machine Components”, Prentice-Hall 1998.
4) D’Souza, A. F., and Garg, V. K., “Advanced Dynamics: Modeling and Analysis”, 2nd edition, Prentice-Hall 1984.

18UMEE834	Tribology and Bearing Design	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Laws of friction, and fluid flow, mechanisms of friction and lubrication friction space, stiction, stick slip, and surface temperature.
2. Various modes of wear: adhesive, delamination, fretting, abrasive, erosive, corrosive and the wear-mechanism maps.
3. Design and applications of sliding contact bearings.
4. Applications of rolling contacts, Magnetic bearing and elimination of leakage using seals.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain laws of fluid flow and different lubrication methods.		1	2
CO-2	Compute power losses and frictional forces in hydrodynamic bearings.	1	2	-
CO-3	Explain different fluid film formation mechanisms in bearings.	-	1	-
CO-4	Analyze pressure distribution around the hydrostatic journal bearing.	1	-	2
CO-5	Discuss different wear mechanisms and advanced bearings and its components.	-	1, 2	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.4	1.5	-	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Nil.

Contents:

Unit - I

Introduction: Properties of oil, equation of flow, absolute viscosity, Hagen Poiseullie's law, flow between parallel stationary plates, apparatus for measuring viscosity, factors that affect viscosity. **8 Hrs**

Unit - II

Hydrodynamic Lubrication: Tower's experiments, Petroff's equation, friction forces, power losses in lightly loaded bearings, mechanism of pressure development in an oil film, numericals on Petroff's equation and oil flow through capillary. **8 Hrs**

Unit - III

Reynolds equation in two dimensional flow: idealized journal bearing friction forces, power losses, pivoted shoe bearing, friction forces, power losses, collar thrust bearing with end leakage, thermal equilibrium.**8 Hrs**

Unit - IV

Hydrostatic Lubrication: Application of hydrostatic lubrication, hydrostatic thrust bearing, introduction to hydrostatic journal bearing and numerical. **8 Hrs**

Unit - V

Wear and abrasion: Wear mechanism, Mechanism of wear in elastomers, wear Measurements.

Introduction: Magnetic and foil bearings, seals and types. **7 Hrs**

Reference Books:

1) E.I. Radzimovsky, "Lubrication of Bearings", The Ronold Press Company, 1959.
2) Suhilkumar Srivastava, "Industrial Tribology", S.C. Chand And Company, 2001.
3) B.C Muzumdar, "Lubrication of Bearings", Wheeler Publishers1996.
4) K. Lingaiah, "Design Data Hand book", Vol2, Suma publishers 1984.

18UMEE835	Failure Analysis	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Role of failure in materials for better sustainability of materials and prevent failure of materials by testing under various loads.
2. The importance failure modes in materials.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Discuss failure criteria and different modes of mechanical failures.	-	1,2	-
CO-2	Apply damage theories to determine failure criteria	1	2	3
CO-3	Use statistics in fatigue analysis	1	2	3
CO-4	Explain concepts of creep, stress rupture and fatigue	-	1,2	-
CO-5	Explain concepts of fretting, wear, and other failure modes	-	1,2	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.4	2	1	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Nil.

Contents:

Unit - I

The role of Failure Prevention Analysis in Mechanical Design: Introduction, Definition of Design, Some Design objectives, Modes of Mechanical failure, definition of failure mode, failure modes observed in practice.

High Cycle fatigue: The nature of fatigue, Fatigue loading, Laboratory fatigue testing, The S-N-P curves-A basic design tool, factors that affect S-N-P curves, The influence of nonzero mean stress, multiaxial fatigue stresses. **8 Hrs**

Unit - II

Concepts of cumulative damage, life prediction, and fracture control: The linear damage theory, Cumulative Damage Theories: Henry Cumulative Damage theory, Gatts Cumulative Damage theory, Martin Cumulative Damage theory, Damage tolerance and fracture control

8 Hrs

Unit - III

Use of Statistics in Fatigue analysis: Definitions, Population Distributions, Sampling Distributions, Statistical Hypotheses, confidence limits, Properties of good estimators, sample size for desired confidence, probability paper.

Fatigue testing Procedures and statistical interpretation of data: Standard method, Constant stress level testing, response or survival method, Prot method, extreme value method.

8 Hrs

Unit - IV

Low cycle fatigue: The strain cycling concept, the strain life cycle curve and low cycle fatigue relationships, the influence of nonzero mean strain and nonzero mean stress, cumulative damage in low cycle fatigue, Influence of multiaxial states of stress, Relationship of thermal fatigue to low cycle fatigue. **7 Hrs**

Unit - V

Creep, stress rupture and fatigue: Prediction of long term creep behavior, Theories for predicting creep behavior, cumulative creep concepts.

Fretting, Fretting fatigue, and Fretting wear: Variables of importance in the Fretting process, Fretting Fatigue, Fretting wear, Fretting Corrosion, minimizing or preventing Fretting damage. Wear, corrosion and other important failure modes. **8 Hrs**

Text Book:

1) Jack A. Collins, “Failure of Materials in Mechanical Design: Analysis, Prediction”, Prevention, 2nd Edition, John Wiley & Sons, 1983.

Reference Books:

1) Richard M Christensen, “Theory of Materials Failure”, Oxford University Press, 2013.
2) Ashok Choudhury, “Failure Analysis of Engineering Materials”, Charles R. Brooks, McGraw Hill Professional, 2002.

18UMEE836	Surface Engineering	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Surface structure and surface engineering basics
2. Basics of wear and corrosion problems
3. The contrasts between different group of surface engineering processes
4. Industrial applications of different surface engineering technique

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1-12)/ PSOs (13,14)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain the basic concepts of friction, wear, corrosion of materials and their types	-	-	1,2
CO-2	Describe the principles of different Surface treatments and coating techniques based on the applications	-	1,2	-
CO-3	Explain different coating techniques and their properties.	-	-	1,2,3
CO-4	Discuss different surface treatment techniques.	-	1,2	3
CO-5	Explain new trends in coating technology and quality testing of coatings	-	-	1,2,3

POs/PSOs	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mapping Level	1.4	1.4	1	-	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Contents:

Unit - I

Introduction to Surface engineering: Philosophy of surface, general applications and requirements. Scope of surface engineering for different engineering materials, Surface Preparation methods such as Chemical, Electrochemical, Mechanical: Sand Blasting, Shot peening, Shot blasting, Hydro-blasting, Vapor Phase Degreasing etc.,
Coatings: Classification, Properties and applications of Various Coatings.

8 Hrs

Unit - II

Mechanisms of Wear and Metal Cleaning: Basic Mechanisms of wear-abrasive, adhesive wear, contact fatigue, Fretting corrosion, Testing of wear resistance, practical diagnosis of wear, general cleaning process for ferrous and non ferrous metals and alloys selection of cleaning processes, alkaline cleaning, emulsion cleaning, ultrasonic cleaning, pickling salt bath descaling, abrasive bath cleaning, polishing and buffing shot peening. **7 Hrs**

Unit - III

Coating: The concept of the coatings, Structure of the coating, Types of coatings: metallic and non-metallic, Classification of coatings, Potential properties of coatings, Geometrical parameters of coatings, Geometric and physic - chemical parameters of coatings, Physio - chemical parameters of coatings, Service properties of coatings: Anti-corrosion properties, Signification of development of coating. Diffusion coating. **8 Hrs**

Unit - IV

Surface Treatments: Introduction – Surface properties, Superficial layer – Changing surface metallurgy – Wear resistant coatings and Surface treatments, Thermal spray processes; Electrodeposited coatings; Physical and chemical vapour deposition techniques; Polymer coatings; Finishing of surface coatings applied by welding and thermal spraying, Laser surface hardening and alloying, Ensuring quality in surfacing, **8 Hrs**

Unit - V

Surface treatments Techniques: Applications of coatings and surface treatments in wear and friction control – Characteristics of Wear resistant coatings – New trends in coating technology – DLC – CNC – Thick coatings – Nano-engineered coatings – Other coatings, Corrosion resistant coatings. Quality Assurance, Testing and Selection of Coatings: The quality plan, design, testing and inspection, thickness and porosity measurement, selection of coatings, industrial applications of engineering coatings **8 Hrs**

Reference Books:

1) T Burakowski and T. Wierzchon, “Surface engineering of metals”, CRC Press.
2) S. Grainger, “Engineering Coatings-design and application”, Jaico Publishing House.
3) Principles of Metals surface treatment and protection- D. R. Gabe, Pergamon.

18UMEE837	Industry 4.0 & Artificial Intelligence	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

4. To present a problem oriented in depth knowledge of Industry 4.0 & Artificial Intelligence
5. To address the underlying concepts, methods and application of Industry 4.0 & Artificial Intelligence

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Develop real life IIoT applications using hardware and software.	1	2	-
CO-2	Explain various IIoT Layers and their relative importance.	-	1,2	-
CO-3	Realize the importance of Data	-	1,2	-

	Analytics in IIoT			
CO-4	Identify appropriate representation & algorithm for an AI problem domain.	-	1,2	-
CO-5	Explain various learning techniques to solve AI problems.	-	1,2	-

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	2.2	2	-	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Nil

Contents:

Unit - I

Industry 4.0: Globalization, the Fourth Revolution, LEAN Production Systems Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis **8 Hrs**

Unit - II

IIoT-Introduction, Industrial IoT: Business Model and Referece Architerture: IIoT-Business Models, Industrial IoT- Layers: IIoT Sensing, IIoT Processing, IIoT Communication, IIoT Networking

Big Data Analytics and Software Defined Networks, Machine Learning and Data Science. **8 Hrs**

Unit - III

Industrial IoT: Security and Fog Computing - Cloud Computing in IIoT, Fog Computing in IIoT, Security in IIoT.

Industrial IoT- Application Domains: Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case studies: Milk Processing and Packaging Industries, Manufacturing Industries. **7 Hrs**

Unit - IV

Introduction to Artificial Intelligence: Applications- Games, theorem proving, natural language processing, vision and speech processing, robotics, expert systems. AI techniques- search knowledge, abstraction.

State space search; Production systems, search space control: depth-first, breadth-first search. Heuristic search - Hill climbing, best-first search, branch and bound. Problem Reduction, Constraint Satisfaction End, Means-End Analysis. **8 Hrs**

Unit - V

Predicate Logic: unification, modus pones, resolution, dependency directed backtracking. Rule based Systems: forward reasoning, conflict resolution, backward reasoning, use of no backtracks. Structured Knowledge Representation: semantic net slots, exceptions and default frames, conceptual dependency, scripts.

Introduction to NLP: Basics of Syntactic Processing, Basics of Semantic Analysis, Basics of Parsing techniques, context free and transformational grammars, transition nets, augmented transition nets, Shanks Conceptual Dependency, Scripts ,Basics of grammar free analyzers, Basics of sentence generation, and Basics of translation. **8 Hrs**

Reference Books:

1) Adastair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, 2017.
2) D. W. Patterson, “Introduction to AI and Expert Systems”, PHI, 1992.
3) Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat, “Industrial Internet of Things: Cyber manufacturing systems”, Springer, 2017.
4) E. Rich and K. Knight, “Artificial intelligence”, 2nd edition, McGraw Hill, 1992.
5) N.J. Nilsson, “Principles of AI”, Narosa Publ. House, 2000.
6) Robin R Murphy, “Introduction to AI Robotics”, PHI Publication, 2000
7) R. J. Schalkoff, “Artificial Intelligence - an Engineering Approach”, McGraw Hill Int. Ed., Singapore, 1992.
8) George Lugar, “Al-Structures and Strategies for and Strategies for Complex Problem solving”, 4th edition, Pearson Education, 2002.

20PEADE322	Scientific Computing	(2-0-1) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. To design a program with a comprehensive study on the basics of Python programming.
2. To demonstrate their knowledge and computer skill in a project and apply it to practical significance.
3. To develop program by applying linear algebra, interpolation and integration to solve problems.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1- 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Examine syntax and semantics error in Python programs.	1	3	-
CO-2	Design a program using lists, flow control and functions.	1	3,4	-
CO-3	Develop Programs using NumPy array and plot the Graphs.	1	3,4	-

CO-4	Solve interdisciplinary problems involving integration, differentiation and interpolation.	1	3,4	-
CO-5	Analyze Images using image processing technique.	1	3	4
CO-6	Solve problems using Python programming and generate report	1	3,4	2

PO's	PO1	PO2	PO3	PO4
Mapping Level	3	1	2	1.8

Prerequisites: Nil

Course Contents:

1. **Introduction:** Introduction to basic of Python, Installing Python, IDE, various code editor, variables, expressions and statements, Conditional execution, Interactive Shell, The Integer, Floating-Point, and String Data Types, String Concatenation and Replication, Storing Values in Variables.**2L+1P Hrs**
2. **Flow Control:** Boolean Values, Comparison Operators, Boolean Operators, Binary Boolean Operators, The not Operator, Flow Control Statements, if Statements, else Statements, elif Statements, while Loop Statements, break Statements, continue Statements, for Loops and the range () Function. **3L+2P Hrs**
3. **List:** Getting Individual Values in a List with Indexes, Negative Indexes, Getting Sub lists with Slices, Getting a List's Length, Changing Values in a List with Indexes, List Concatenation and List Replication, Removing Values from Lists with del Statements, Working with Lists, Using for Loops with Lists, The in and not in Operators. **3L+2P Hrs**
4. **Functions:** The def Statements with Parameters, Return Values and return Statements, The None Value, Keyword Arguments and print(), Local and Global Scope. **2L+1P Hrs**
5. **Numerical computation** (**Numpy):** Basic array methods, Reading and writing an array to a file, Polynomials, Linear algebra, Matrices, Random sampling, Discrete Fourier transforms. Matplotlib: Introduction, Matplotlib basics, Contour plots, 3D plots. **5L+3P Hrs**
6. **Mathematical operations (SciPy):** Introduction to SciPy, Ordinary differential equations, Numerical integration, optimization, random number generation, Interpolation, data-fitting and root-finding. **6L+2P Hrs**
7. **Image Processing:** Concepts in Image Processing, changing color-space, Read Image, Resize Image, Blur Image, Geometric transformation of an image, smoothing image, contours. **5L+2P Hrs**

Activity Beyond Syllabus: Solving real-time application problems using Python software.

Text Books:

1. Christian Hill, “Learning Scientific Programming with Python”, Cambridge University Press, 2015

Reference Books:

1. Charles Dierbach, "Introduction to Computer Science Using Python", 1st Edition, Wiley India Pvt Ltd. 2015
2. T.R. Padmanabhan, “Programming with Python”, Springer, 2016
3. Hans Petter Langtangen, “A Primer on Scientific Programming with Python”, Springer; 3rd ed, 2012.
4. Ashwin Pajankar,“Python 3 Image Processing”, 1st Edition, PBP Publication, 2019

20PEADE312 Mathematical Modeling for Engineering Systems (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. To integrate and utilize Core knowledge, enabling them to analyze open-ended problems.
2. To demonstrate their knowledge of a project or structured experience of practical significance.
3. Fundamentals of deterministic models in the discrete-time domain
4. To perform modelling and enhance the problem-solving capability

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1- 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Apply key mathematical and statistical techniques for solving problems in engineering analysis	1,3	-	4
CO-2	Assess and analyze linear regression and model fitting data	1	3, 4	-
CO-3	Interpret results of modelling of polynomial functions.	1	4	3
CO-4	Develop models for experimental domain and execute simulation modelling.	1	3, 4	-
CO-5	Optimize graphics models for a given functions.	1	3, 4	-

CO-6	Construct and analyze a mathematical model of a given physical system.	1, 4	3	-

PO's	PO1	PO2	PO3	PO4
Mapping Level	3	-	1.8	1.8

Prerequisites: Nil

Contents:

1. **Introduction:** The need for Mathematical modelling and types of mathematical models, modelling concepts, modelling change with difference equation, approximation change with the difference equation, the solution to dynamic solutions. The Modeling Process: Mathematical models, modelling using Proportionality, Modeling using Geometric similarity. **8 Hrs**
2. **Linear regression:** Modelling with exponential functions, fitting linear models to data. Evaluating model error; the sum of squared errors, Interpreting the correlation coefficient, Exponential growth functions with applications, Growth factors and rates, Doubling time, Compound interest, exponential decay functions with applications, Decay factors and rates. Model Fitting: Introduction, Fitting models to data graphically, Analytical Methods of Model Fitting, Applying the Least-Squares Criterion. **8 Hrs**

3. **Modeling with polynomial functions:** Quadratic functions with applications, Projectile motion, Maxima and minima applications, fitting quadratic models to data, interpreting the coefficient of determination. Polynomial functions of higher degree with applications, Polynomial interpolation, Fitting cubic and quartic models to data. **7 Hrs**

4. **Experimental and Simulation Modeling:** Introduction, one term models, higher-order Polynomial Model, Lower order Polynomial Model. Introduction to simulation modeling, simulating deterministic Behavior, generating random numbers, Simulating Probabilistic Behavior, Inventory model, Queuing Model. **8 Hrs**

5. **Discrete Optimization Modeling:** Introduction, Linear Programming: Geometrical solution, Graphical Solution, The simplex method and sensitivity analysis. Constrained optimization.
   Applications of graph theory: Basic graph theory; graph coloring; shortest path; minimum spanning tree; maximum flow; matching; vertex cover.
   8 Hrs

Text Book:

1. Giordano, F. R., Fox W. P., and Horton S. B. The first course in mathematical modelling, 3rd Edition, Thomson Brooks. 2014

Reference Books:

1. Mesterton - Gibbons, M. A concrete approach to mathematical modelling. Addison-Wesley, 1988.
2. Roberts, F. S. Discrete mathematical models. Prentice-Hall, 1976.
3. D. Basmadjian, Mathematical Modeling of Physical Systems, Oxford Press. 2003
4. Walter J. Meyer, Concepts of Mathematical Modeling, Dover Publications 2012.

20PEADE313	Surface Engineering	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

5. Surface structure and surface engineering basics
6. Basics of wear and corrosion problems
7. The contrasts between different group of surface engineering processes
8. Industrial applications of different surface engineering technique

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain the basic concepts of friction, wear, corrosion of materials and their types	-	-	1
CO-2	Describe the principles of different Surface treatments and coating techniques based on the applications	-	-	1
CO-3	Explain different coating techniques and their properties.	-	-	1
CO-4	Discuss different surface treatment techniques.	-	-	1
CO-5	Explain new trends in coating technology and quality testing of coatings	-	-	1

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	1	-	-	-	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Contents:

1. **Introduction to Surface engineering:** Philosophy of surface, general applications and requirements. Scope of surface engineering for different

engineering materials, Surface Preparation methods such as Chemical, Electrochemical, Mechanical: Sand Blasting, Shot peening, Shot blasting, Hydro-blasting, Vapor Phase Degreasing etc.,

Coatings: Classification, Properties and applications of Various Coatings. **8 Hrs**

2. **Mechanisms of Wear and Metal Cleaning:** Basic Mechanisms of wear-abrasive, adhesive wear, contact fatigue, Fretting corrosion, Testing of wear resistance, practical diagnosis of wear, general cleaning process for ferrous and non ferrous metals and alloys selection of cleaning processes, alkaline cleaning, emulsion cleaning, ultrasonic cleaning, pickling salt bath descaling, abrasive bath cleaning, polishing and buffing shot peening. **7 Hrs**
3. **Coating**: The concept of the coatings, Structure of the coating, Types of coatings: metallic and non-metallic, Classification of coatings, Potential properties of coatings, Geometrical parameters of coatings, Geometric and physic - chemical parameters of coatings, Physio - chemical parameters of coatings, Service properties of coatings: Anti-corrosion properties, Signification of development of coating. Diffusion coating. **8 Hrs**
4. **Surface Treatments**: Introduction – Surface properties, Superficial layer – Changing surface metallurgy – Wear resistant coatings and Surface treatments, Thermal spray processes; Electrodeposited coatings; Physical and chemical vapour deposition techniques; Polymer coatings; Finishing of surface coatings applied by welding and thermal spraying, Laser surface hardening and alloying, Ensuring quality in surfacing, **8 Hrs**
5. **Surface treatments Techniques:** Applications of coatings and surface treatments in wear and friction control – Characteristics of Wear resistant coatings – New trends in coating technology – DLC – CNC – Thick coatings – Nano-engineered coatings – Other coatings, Corrosion resistant coatings.
   Quality Assurance, Testing and Selection of Coatings: The quality plan, design, testing and inspection, thickness and porosity measurement, selection of coatings, industrial applications of engineering coatings **8 Hrs**

Reference Books:

4) T Burakowski and T. Wierzchon, “Surface engineering of metals”, CRC Press.
5) S. Grainger, “Engineering Coatings-design and application”, Jaico Publishing House.
6) Principles of Metals surface treatment and protection- D. R. Gabe, Pergamon.

20PEADE333	Industrial Robotics	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. Various elements of Robotics.
2. Kinematics of robots.
3. Modeling and analysis concepts of various robotics systems.
4. Trajectory planning and various sensors used in robotics.

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain basic structure and performance characteristics of an industrial robot.	-	1	-
CO-2	Describe different types of sensors and vision system in a robot.	-	1	-
CO-3	Derive a mathematical model and equations of motion for a robot.	-	-	3
CO-4	Analyze kinematically serial manipulators.	-	-	1
CO-5	Plan the motion of robot using different trajectory planning schemes and explain types of end effectors.	-	-	1

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	1.5	-	1	-	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Contents:

1. **Introduction:** Definition: manipulators, Robotics, Brief history of robotics, Overview of robots, social & economic aspects of robots, Advantages of using robots in industries, Future applications. **Structure of robotic systems:** Classification, Geometrical configuration, wrist & its motions, Degrees of freedom, work Envelop, Links and joint, effectors and its type, Robot drive system: Hydraulic, electric selection of drive system, Resolution, accuracy & repeatability, Specifications of robots. **8 Hrs**
2. **Sensors:** State and Transducers, Classification, Internal & External sensors, Interlocks, Tactile and non- tactile sensors, Proximity and range sensing, force

– torque, Static and dynamic characteristics, Selection of sensors, Elements of computer vision, Sensing and digitizing, Lighting techniques, A/D conversion, sampling quantization, Image storage, Image processing and analysis, Feature Extraction &object Recognition.**Robot Programming:** Introduction, Types robot programming, Teach pendant, Lead through programming, Programming languages VAL, RAIL, AML, Programming with graphics, storing & operating. **8 Hrs**

3. **Robot Motion Analysis:** Kinematics, Introduction, Direct & inverse kinematics, Classification, Transformations homogenous transformations, Rotation, matrix, Composite rotation matrix, Rotation matrix about an arbitrary axis, Euler angle representation, Links, joints and their parameters D-H representation. **10 Hrs**
4. **Robot Arm Dynamics:** Euler Lagrange formulations, Joint velocities, K.E., P.E, motion equations of a robot manipulator.**Control Systems and Components:** Basic control system concepts and models, Transfer function with block diagram of spring mass system, Transient response to second order systems, controllers on/off, proportional and integral, PID, Digital, Adoptive control, AI. **7 Hrs**
5. **Trajectory Planning:** Introduction, General considerations on trajectory planning, Joint interpolated trajectories, 4-3-4 trajectory examples, Planning of Cartesian path Trajectories. **Robot End Effectors:** types of end effectors, Mechanical Grippers, Other types of Grippers, tools as End effectors, the robot/end effector interface, considerations in gripper selection and design. **6 Hrs**

Text Book:

1) Mohsen Shahinpoor, “A Robot Engineering Textbook”, Harper & Row.

Reference Books:

1) Mikell P Grover, Mitchel Weiss, Roger N Nagel, Nicholas G Odrey & Ashish Dutta, “Industrial Robots”, McGraw Hill, 2003.
2) K.S. Fu, R. C. Gonzalez & C.S.G. Lee, “Robotics- control, sensing, vision and intelligence”, McGraw Hill, International, New Delhi 2001.
3) Yoram Koren, “Robotics for Engineers”, McGraw Hill International, New Delhi 2001.
4) Richard Paul, “Robot manipulators-Mathematics, Programming and control”, 2000.
5) Saeed B. Niku, “Introduction to Robotics”, Wiley student edition, second edition, 2011.
6) S. K. Saha, “Introduction to Robotics”, McGraw Hill, second edition, 2015.

20PEADE323	**Industry 4.0 & Artificial Intelligence**	**(3-0-0) 3**

Contact Hours: 39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

6. To present a problem oriented in depth knowledge of Industry 4.0 & Artificial Intelligence
7. To address the underlying concepts, methods and application of Industry 4.0 & Artificial Intelligence

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13,14)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Develop real life IIoT applications using hardware and software.	-	-	1
CO-2	Explain various IIoT Layers and their relative importance.	-	-	1
CO-3	Realize the importance of Data Analytics in IIoT	-	-	1
CO-4	Identify appropriate representation & algorithm for an AI problem domain.	-	-	1
CO-5	Explain various learning techniques to solve AI problems.	-	-	1

POs/PSOs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Mapping Level	1	-	-	-	-	-	-	-	-	-	-	-	-	-

Pre requisites: Nil

Contents:

1. **Industry 4.0:** Globalization, the Fourth Revolution, LEAN Production Systems Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis **8 Hrs**
2. **IIoT-Introduction, Industrial IoT:** Business Model and Referece Architerture: IIoT-Business Models, Industrial IoT- Layers: IIoT Sensing, IIoT Processing, IIoT Communication, IIoT Networking. Big Data Analytics and Software Defined Networks, Machine Learning and Data Science. **8 Hrs**
3. **Industrial IoT:** Security and Fog Computing - Cloud Computing in IIoT, Fog Computing in IIoT, Security in IIoT. **Industrial IoT- Application Domains:** Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case studies: Milk Processing and Packaging Industries, Manufacturing Industries. **7 Hrs**
4. **Introduction to Artificial Intelligence:** Applications- Games, theorem proving, natural language processing, vision and speech processing, robotics,

expert systems. AI techniques- search knowledge, abstraction. State space search; Production systems, search space control: depth-first, breadth-first search. Heuristic search - Hill climbing, best-first search, branch and bound. Problem Reduction, Constraint Satisfaction End, Means-End Analysis.

8 Hrs

5. **Predicate Logic:** unification, modus pones, resolution, dependency directed backtracking. Rule based Systems: forward reasoning, conflict resolution, backward reasoning, use of no backtracks. Structured Knowledge Representation: semantic net slots, exceptions and default frames, conceptual dependency, scripts. **Introduction to NLP:** Basics of Syntactic Processing, Basics of Semantic Analysis, Basics of Parsing techniques, context free and transformational grammars, transition nets, augmented transition nets, Shanks Conceptual Dependency, Scripts ,Basics of grammar free analyzers, Basics of sentence generation, and Basics of translation.

8 Hrs

Reference Books:

1) Adastair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, 2017.
2) D. W. Patterson, “Introduction to AI and Expert Systems”, PHI, 1992.
3) Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat, “Industrial Internet of Things: Cyber manufacturing systems”, Springer, 2017.
4) E. Rich and K. Knight, “Artificial intelligence”, 2nd edition, McGraw Hill, 1992.
5) N.J. Nilsson, “Principles of AI”, Narosa Publ. House, 2000.
6) Robin R Murphy, “Introduction to AI Robotics”, PHI Publication, 2000
7) R. J. Schalkoff, “Artificial Intelligence - an Engineering Approach”, McGraw Hill Int. Ed., Singapore, 1992.
8) George Lugar, “Al-Structures and Strategies for and Strategies for Complex Problem solving”, 4th edition, Pearson Education, 2002.

22PEADC101	Continuum Mechanics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

The course will provide a basic treatment of the formulation of linear elasticity theory and its application to problems of stress and displacement analysis. The fundamental field equations will be developed including strain energy concepts. Applications will involve the solution to problems of engineering interest including two-dimensional problems of plane strain, plane stress, torsion, and bending.

Course Outcomes (COs):

Description of the course outcome: At the end of the course the student will be able to:		**Mapping to POs(1-4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Analyze the concept of stress at a point, equilibrium equations and Solve problems on principal stress and stress transformation.	1,3	-	4
CO-2	Analyze strain at a point and derive strain compatibility equations and solve problems on strain transformation.	1,3	-	4
CO-3	Deduce equations on stress-strain relations using engineering constants and solve problems.	1,3	-	4
CO-4	Solve governing differential equations for 2-D problems in rectangular and polar co-ordinate system for different systems.	1,3	-	4
CO-5	Apply membrane analogy for non-circular members, thin tubes under torsion and solve problems.	-	1,3	4

POs	PO1	PO2	PO3	PO4
Mapping Level	2.8	-	2.8	1

Pre requisites: Strength of materials, applied mathematics, material science.

Course contents:

1. **Analysis of Stress:** Definition and notation of stress; differential equations of equilibrium; specification of stress at a point; principal stresses; boundary conditions in terms of surface forces. **10 Hrs**
2. **Analysis of Strain**: Strain components; specification of strain at a point; compatibility equations. **6 Hrs**
3. **Stress-Strain Relations:** Generalized Hooke's law; Generalized Hooke's law in terms of engineering elastic constants; strain energy; general theorems – uniqueness theorem, principle of superposition, saint venants principle. **8 Hrs**
4. **Plane stress and plane strain problems:** Governing differential equations; Airy's stress function; 2-D problems in rectangular and polar co-ordinates; Bending of cantilever loaded at the end; bending of simply supported beam by uniform load; Thick cylinder under uniform pressure; Shrink fits; Effect of small circular holes in strained plates; stresses in rotating discs and cylinders; rotating disc of variable thickness; Thermal stresses in thin discs and long cylinders. **10 Hrs**
5. **Torsion:** Torsion of circular and elliptical bars; Membrane analogy, Torsion of thin open sections, torsion of thin tubes. **6 Hrs**

6. **Energy principles:** Principle of potential energy; principle of complimentary energy; the principles of potential and complimentary energy considered as variational principles; Rayleigh-Ritz method; galerkin method; reciprocal theorem and Castiglione's theorems. **6 Hrs**
7. **Bending of thin plates:** Differential equation for the bending of thin plates, boundary conditions, bending of simply supported rectangular plates with clamped edges. **6 Hrs**

Text Book:

1. L.S.Srinath. Advanced Mechanics of Solids. McGraw Hill Education; 3rd edition. 2002

Reference Books:

1. C.T.Wang "Applied Elasticity" McGraw Hill Book Co. Inc 1953
2. S.P.Timoshenko and J.N.Goodier "Theory of Elasticity" 3rd Ed, McGraw Hill, 1970.

22PEADC102	Advanced Finite Element Methods	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

6. To use variational principles for solving problems in solid mechanics.
7. To explain basic procedure of FEM for different types of problems.
8. To formulate different types of problems using different elements using FEM.
9. To solve basic problems on dynamic analysis using FEM.

Course Outcomes (COs):

Description of the course outcome: At the end of the course the student will be able to:	**Mapping to POs(1-4)**		
	Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**

CO-1	Solve basic problems in solid mechanics using variational and other principles	1	-	3
CO-2	Discuss basic concepts of FEM.	-	1	3
CO-3	Develop finite element formulation for bars, trusses and beams.	-	3	4
CO-4	Develop finite element formulation using different 1D, 2D and 3D elements.	3	-	4
CO-5	Solve solid mechanics and heat transfer problems using 1D, 2D and 3D elements.	4	3	-
CO-6	Perform dynamic analysis using finite element method for 1D and 2D problems.	1	4	-

POs	PO1	PO2	PO3	PO4
Mapping Level	2.3	-	1.6	1.8

Pre requisites: Matrix operations and calculus, Strength of Materials, Theory of Elasticity

Course Contents:

1. **Introduction to Finite Element Method:** Basic Steps in Finite Element Method to solve mechanical engineering (Solid, Fluid and Heat Transfer) problems: Functional approach and Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non-Conforming elements, Co C1 and Cn Continuity Elements. Basic Equations, Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions. **10 Hrs**
2. **Solid Mechanics:** One-Dimensional Finite Element Formulations and Analysis – Bars- uniform, varying and stepped cross section-Basic(Linear) and Higher Order Elements Formulations for Axial, Torsional and Temperature Loads with problems. Beams- Basic (Linear) Element Formulation-for uniform, varying and stepped cross section- for different loading and boundary conditions with problems. Trusses, Plane Frames and Space Frame Basic (Linear) Elements Formulations for different boundary condition-Axial, Bending, Torsional, and Temperature Loads with problems. **11 Hrs**
3. **Two Dimensional Finite Element Formulations for Solid Mechanics Problems:** Triangular Membrane (TRIA 3, TRIA 6, TRIA 10) Element, Four-Noded Quadrilateral Membrane (QUAD 4, QUAD 8) Element Formulations for in-plane loading with sample problems. Triangular and Quadrilateral Axi-symmetric basic and higher order Elements formulation for axi-symmetric

loading only with sample problems Three Dimensional Finite Element Formulations for Solid Mechanics Problems: Finite Element Formulation of Tetrahedral Element (TET 4, TET 10), Hexahedral Element (HEXA 8, HEXA 20), for different loading conditions. Serendipity and Lagrange family Elements. **11 Hrs**

4. **Finite Element Formulations for Structural Mechanics Problems:** Basics of plates and shell theories: Classical thin plate Theory, Shear deformation Theory and Thick Plate theory. Finite Element Formulations for triangular and quadrilateral Plate elements. Finite element formulation of flat, curved, cylindrical and conical Shell elements. **10 Hrs**
5. **Dynamic Analysis:** Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one dimensional dynamic analysis: bar, truss, frame and beam element. Finite Element Formulation of Two dimensional dynamic analysis: triangular membrane and axisymmetric element, quadrilatateral membrane and axisymmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame. **10 Hrs**

Text Books:

1. Rao S. S. “Finite Elements Method in Engineering” 4th Edition, Elsevier, 2006
2. T. R. Chandrupatla and A. D. Belegundu, “Introduction to Finite Elements in Engineering”, Prentice Hall,Ed, 2002.

Reference Books:

1. P.Seshu, “Textbook of Finite Element Analysis” PHI, 2004.
2. Bathe K. J. “Finite Element Procedures” Prentice-Hall, 2006.
3. Cook R. D “Finite Element Modeling for Stress Analysis” Wiley,1995
4. T. R. Chandrupatla and A. D. Belegundu, “Introduction to Finite Elements in Engineering” Prentice Hall, 3rd Ed, 2002.
5. Lakshminarayana H. V “Finite Elements Analysis– Procedures in Engineering” Universities Press, 2004.

22PEADE222	Additive Manufacturing Technology	(3-0-0) 3

Contact Hours:39

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. The need and importance of Rapid Prototyping methods in design process and in other applications.
2. Realize the basic working principle of various Rapid Prototyping techniques.
3. An insight of Rapid Prototypes those are used as Concept modelers.
4. The importance and working of Rapid Tooling methods and the various software's in RP.
5. Recognize the Rapid Prototyping process optimization parameters in building the physical models.

Course Outcomes:

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1,4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Discuss various Rapid Prototyping Methods.	-	1	3

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CO-2	Apply CAD modeling and data processing methods for various Rapid Prototyping techniques.	1,3	-	4
CO-3	Describe Photo polymerization, Powder Bed Fusion and Extrusion in Rapid prototyping.	-	1,3	-
CO-4	Discuss 3D printing, Sheet Lamination and Beam Deposition techniques.	-	1,3	4
CO-5	Compare various Rapid Tooling methods.	-	1,3	4
CO-6	Identify the various Rapid Prototyping process parameters and optimize these parameters.	-	1,3	-

POs	PO1	PO2	PO3	PO4
Mapping Level	2.2	-	2	1

Pre requisites: CAD/CAM, Manufacturing engineering, Tool Design.

Course contents:

1. **Introduction:** Introduction to Prototyping, Traditional Prototyping Vs. Rapid Prototyping (RP), Need for time compression in product development, Usage of RP parts, Generic RP process, Distinction between RP and CNC, other related technologies, Classification of RP.

   4 Hrs

2. **CAD Modelling and Data Processing for RP:** CAD model preparation, Data Requirements, Data formats (STL, SLC, CLI, RPI, LEAF, IGES, HP/GL, CT, STEP), Data interfacing, Part orientation and support generation, Support structure design, Model Slicing and contour data organization, direct and adaptive slicing, Tool path generation.

   4 Hrs

3. **RP Systems: Photo polymerization:** Stereo lithography (SL) SL resin curing process, SL scan patterns, Micro stereo lithography, Applications of Photo polymerization Processes.

   Powder Bed Fusion: Selective laser Sintering (SLS), Powder fusion mechanism and powder handling, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Applications of Powder Bed Fusion Processes.

   Extrusion-Based RP Systems: Fused Deposition Modelling (FDM), Principles, Plotting and path control, Applications of Extrusion-Based Processes.

3D Printing: 3D printing (3DP), Research achievements in printing deposition, Technical challenges in printing, Printing process modelling, Applications of Printing Processes.

Sheet Lamination: Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications.

Beam Deposition: Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Processing-structure-properties, relationships, Benefits and drawbacks.

14 Hrs

4. **Concepts Modelers:** Principle, Thermal jet printer, Sander's model market, 3-D printer, GenisysXs printer HP system 5, object Quadra systems. **4 Hrs**
5. **Rapid Tooling:** Conventional Tooling Vs. Rapid Tooling, Classification of Rapid Tooling, Direct and Indirect Tooling Methods, Soft and Hard Tooling methods. Indirect Rapid tooling -Silicon rubber tooling—Aluminum filled epoxy tooling, Spray metal tooling ,Cast kirksite ,3D keltool ,etc .Direct Rapid Tooling- Direct, AIM, Quick cast process, Copper polyamide, Rapid Tool, DMLS. **7 Hrs**
6. **Errors in RP Processes:** Pre-processing, processing, post-processing errors, Part building errors in SLA, SLS. **3 Hrs**
7. **RP Applications:** Design, Engineering Analysis and planning applications, Rapid Tooling, Reverse Engineering, Medical Applications of RP. **3 Hrs**

Text Books:

1. Pham D.T. and Dimov S.S., "Rapid Manufacturing; the technologies and application of RPT and Rapid tooling", Springer, London 2001.
2. Chua Chee Kai, Leong Kah Fai, Chu Sing Lim, Rapid Prototyping: Principles and Applications in Manufacturing, World Scientific, 2010.

Reference Books:

1. Ian Gibson, David W Rosen, Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.
2. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.Burns. M, "Automated Fabrication", PHI, 1993.
3. Chua. C.K, "Rapid Prototyping", Wiley, 1997.
4. Jacohs P.F., "Stereo lithography and other Rapid Prototyping and Manufacturing Technologies", ASME, 1996.

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