VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELAGAVI

MECHANICAL ENGINEERING

BE/B.Tech. Scheme of Teaching and Examinations

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

(Effective from the academic year 2018 – 19)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination 2018 – 19
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2018 – 19)

III SEMESTER

Sl. No	Course and Course Code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	BSC	18MAT31	Transform calculus, fourier series and Numerical techniques	Mathematics	2	2	--	03	40	60	100	3
2	PCC	18ME32	Mechanics of Materials		3	2	--	03	40	60	100	4
3	PCC	18ME33	Basic Thermodynamics		3	0	--	03	40	60	100	3
4	PCC	18ME34	Material Science		3	0	--	03	40	60	100	3
5	PCC	18ME35A or	Metal cutting and forming		3	0	--	03	40	60	100	3
		18ME35B	Metal Casting and Welding									
6	PCC	18ME36A or	Computer Aided Machine Drawing/		1	4	--	03	40	60	100	3
		18ME36B	Mechanical Measurements and Metrology		3	0						
7	PCC	18MEL37A or	Material Testing lab		--	2	2	03	40	60	100	2
		18MEL37B	Mechanical Measurements and Metrology lab									
8	PCC	18MEL38A	Workshop and Machine Shop Practice (Consists of Fitting, and Machining)		--	2	2	03	40	60	100	2
		18MEL38B	Foundry,Forging and Welding lab									
9	HSMC	18KVK39/49	Vyavaharika Kannada (Kannada for communication)/	HSMC	--	2	--	--	100	--	100	1
		18KAK39/49	Aadalitha Kannada (Kannada for Administration)									
		OR										
		18CPC39	Constitution of India, Professional Ethics and Cyber Law		1	--	--	02	40	60		
					Examination is by objective type questions							
				TOTAL	**17**	**10**	**04**	**24**	**420**	**480**	**900**	**24**
					OR	**OR**		**OR**	**OR**	**OR**		
					19	**14**		**26**	**360**	**540**		

Note: BSC: Basic Science, PCC: Professional Core, HSMC: Humanity and Social Science, NCMC: Non-credit mandatory course.

18KVK39 Vyavaharika Kannada (Kannada for communication) is for non-Kannada speaking, reading and writing students and 18KAK39 Aadalitha Kannada (Kannada for Administration) is for students who speak, read and write Kannada.

Course prescribed to lateral entry Diploma holders admitted to III semester of Engineering programs

10	NCMC	18MATDIP31	Additional Mathematics - I	Mathematics	02	01	--	03	40	60	100	0

a) The mandatory non – credit courses Additional Mathematics I and II prescribed for III and IV semesters respectively, to the lateral entry Diploma holders admitted to III semester of BE/B. Tech programs, shall attend the classes during the respective semesters to complete all the formalities of the course and appear for the University examination. In case, any student fails to register for the said course/ fails to secure the minimum 40 % of the prescribed CIE marks, he/she shall be deemed to have secured F grade. In such a case, the students have to fulfill the requirements during subsequent semester/s to appear for SEE.

b) These Courses shall not be considered for vertical progression, but completion of the courses shall be mandatory for the award of degree.

Courses prescribed to lateral entry B. Sc degree holders admitted to III semester of Engineering programs

Lateral entrant students from B.Sc. Stream, shall clear the non-credit courses Engineering Graphics and Elements of Civil Engineering and Mechanics of the First Year Engineering Programme. These Courses shall not be considered for vertical progression, but completion of the courses shall be mandatory for the award of degree.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination 2018 – 19
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2018 – 19)

IV SEMESTER

Sl. No	Course and Course Code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	BSC	18MAT41	Mathematics	Mathematics	2	2	--	03	40	60	100	3
2	PCC	18ME42	Applied Thermodynamics		3	2	--	03	40	60	100	4
3	PCC	18ME43	Fluid Mechanics		3	0	--	03	40	60	100	3
4	PCC	18ME44	Kinematics of Machines		3	0	--	03	40	60	100	3
5	PCC	18ME45A	Metal cutting and forming		3	0	--	03	40	60	100	3
		18ME45B	Metal Casting and Welding									
6	PCC	18ME46A or	Computer Aided Machine Drawing/		1	4	--	03	40	60	100	3
		18ME46B	Mechanical Measurements and Metrology		3	0						
7	PCC	18MEL47A or	Material Testing lab		--	2	2	03	40	60	100	2
		18MEL47B	Mechanical Measurements and Metrology lab									
8	PCC	18MEL48A	Workshop and Machine Shop Practice (Consists of Fitting, and Machining)		--	2	2	03	40	60	100	2
		18MEL48B	Foundry, Forging and Welding lab									
9	HSMC	18KVK49/49	Vyavaharika Kannada (Kannada for communication)/	HSMC	--	2	--	--	100	--	100	1
		18KAK49/49	Aadalitha Kannada (Kannada for Administration)									
		OR										
		18CPH49	Constitution of India, Professional Ethics and Cyber Law		1	--	--	02	40	60		
					Examination is by objective type questions							
				TOTAL	**17**	**10**	**04**	**24**	**420**	**480**	**900**	**24**
					OR	**OR**		**OR**	**OR**	**OR**		
					19	**14**		**26**	**360**	**540**		

18KVK39 Vyavaharika Kannada (Kannada for communication) is for non-Kannada speaking, reading and writing students and 18KAK39 Aadalitha Kannada (Kannada for Administration) is for students who speak, read and write Kannada.

Course prescribed to lateral entry Diploma holders admitted to III semester of Engineering programs

10	NCMC	18MATDIP31	Additional Mathematics - I	Mathematics	02	01	--	03	40	60	100	0

(a) The mandatory non – credit courses Additional Mathematics I and II prescribed for III and IV semesters respectively, to the lateral entry Diploma holders admitted to III semester of BE/B. Tech programs, shall attend the classes during the respective semesters to complete all the formalities of the course and appear for the University examination. In case, any student fails to register for the said course/ fails to secure the minimum 40 % of the prescribed CIE marks, he/she shall be deemed to have secured F grade. In such a case, the student have to fulfill the requirements during subsequent semester/s to appear for SEE.

(b) These Courses shall not be considered for vertical progression, but completion of the courses shall be mandatory for the award of degree.

Courses prescribed to lateral entry B. Sc degree holders admitted to III semester of Engineering programs

Lateral entrant students from B.Sc. Stream, shall clear the non-credit courses Engineering Graphics and Elements of Civil Engineering and Mechanics of the First Year Engineering Programme. These Courses shall not be considered for vertical progression, but completion of the courses shall be mandatory for the award of degree.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination 2018 – 19
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2018 – 19)

V SEMESTER

Sl. No	Course and Course code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	PCC	18ME51	Management and Economics		2	2	--	03	40	60	100	3
2	PCC	18ME52	Design of Machine Elements I		3	2	--	03	40	60	100	4
3	PCC	18ME53	Dynamics of Machines		3	2	--	03	40	60	100	4
4	PCC	18ME54	Turbo Machines		3	--	--	03	40	60	100	3
5	PCC	18ME55	Fluid Power Engineering		3	--	--	03	40	60	100	3
6	PCC	18ME56	Operations Management		3	--	--	03	40	60	100	3
7	PCC	18MEL57	Fluid Mechanics/Machines lab		--	2	2	03	40	60	100	2
8	PCC	18MEL58	Energy Conversion Lab		--	2	2	03	40	60	100	2
9	HSMC	18CIV59	Environmental Studies	Civil/ Environmental [Paper setting: Civil Engineering Board]	1	--	--	02	40	60	100	1
				TOTAL	**18**	**10**	**04**	**26**	**360**	**540**	**900**	**25**

Note: PCC: Professional Core, HSMC: Humanity and Social Science.

AICTE activity Points: In case students fail to earn the prescribed activity Points, Eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of degree only after the release of the Eighth semester Grade Card.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination 2018 – 19
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2018 – 19)

VI SEMESTER

Sl. No	Course and Course code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	PCC	18ME61	Finite Element Methods		3	2	--	03	40	60	100	4
2	PCC	18ME62	Design of Machine Elements II		3	2	--	03	40	60	100	4
3	PCC	18ME63	Heat Transfer		3	2	--	03	40	60	100	4
4	PEC	18ME64X	Professional Elective -1		3	--	--	03	40	60	100	3
5	OEC	18ME65X	Open Elective -A		3	--	--	03	40	60	100	3
6	PCC	18MEL66	Computer Aided Modelling and Analysis Lab		--	2	2	03	40	60	100	2
7	PCC	18MEL67	Heat Transfer Lab		--	2	2	03	40	60	100	2
8	MP	18MEMP68	Mini-project		--	--	2	03	40	60	100	2
9	Internship	--	Internship	To be carried out during the vacation/s of VI and VII semesters and /or VII and VIII semesters.								
				TOTAL	**15**	**10**	**06**	**24**	**320**	**480**	**800**	**24**

Note: PCC: Professional core, PEC: Professional Elective, OE: Open Elective, MP: Mini-project.

Professional Elective -1

Course code under 18XX64X	Course Title	Course code under 18XX64X	Course Title
18ME641	**Non-Traditional Machining**	18ME644	**Vibrations and Noise Engineering**
18ME642	**Refrigeration and Air conditioning**	18ME645	**Composite Materials Technology**
18ME643	**Theory of Elasticity**	18ME646	**Entrepreneurship Development**

Open Elective -A

Students can select any one of the open electives offered by other Departments expect those that are offered by the parent Department (Please refer to the list of open electives under 18XX65X).

Selection of an open elective shall not be allowed if,

- The candidate has studied the same course during the previous semesters of the programme.
- The syllabus content of open elective is similar to that of the Departmental core courses or professional electives.
- A similar course, under any category, is prescribed in the higher semesters of the programme.

Registration to electives shall be documented under the guidance of Programme Coordinator/ Advisor/Mentor.

Mini-project work:

Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary Mini- project can be assigned to an individual student or to a group having not more than 4 students.

CIE procedure for Mini-project:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.

The CIE marks awarded for the Mini-project work, shall be based on the evaluation of project report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group wise at the college level with the participation of all the guides of the college. The CIE marks awarded for the Mini-project, shall be based on the evaluation of project report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

SEE for Mini-project:

(i) Single discipline: Contribution to the Mini-project and the performance of each group member shall be assessed individually in the semester end examination (SEE) conducted at the department.

(ii) Interdisciplinary: Contribution to the Mini-project and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted separately at the departments to which the student/s belongs to.

Internship: All the students admitted to III year of BE/B. Tech shall have to undergo mandatory internship of 4 weeks during the vacation of VI and VII semesters and /or VII and VIII semesters. A University examination shall be conducted during VIII semester and the prescribed credit shall be included in VIII semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared fail and shall have to complete during subsequent University examination after satisfying the internship requirements.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination 2018 – 19
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2018 – 19)

VII SEMESTER

Sl. No	Course and Course code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	PCC	18ME71	Control Engineering		3	--	--	03	40	60	100	3
2	PCC	18ME72	Computer Aided Design and Manufacturing		3	--	--	03	40	60	100	3
3	PEC	18ME73X	Professional Elective - 2		3	--	--	03	40	60	100	3
4	PEC	18ME74X	Professional Elective - 3		3	--	--	03	40	60	100	3
5	OEC	18ME75X	Open Elective -B		3	--	--	03	40	60	100	3
6	PCC	18MEL76	Computer Integrated Manufacturing Lab		--	2	2	03	40	60	100	2
	PCC	18MEL77	Design Lab		--	2	2	03	40	60	100	2
7	Project	18MEP78	Project Work Phase - 1		--	--	2	--	100	--	100	1
8	Internship	--	Internship	(If not completed during the vacation of VI and VII semesters, it shall be carried out during the vacation of VII and VIII semesters)								
				TOTAL	**15**	**04**	**06**	**18**	**340**	**360**	**700**	**20**

Professional Elective - 2

Course code under 18XX73X	Course Title	Course code under 18XX73X	Course Title
18ME731	**Design for Manufacture**	18ME734	**Total Quality Management**
18ME732	**Automation and Robotics**	18ME735	**Operations Research**
18ME733	**Computational Fluid Dynamics**		

Professional Electives - 3

Course code under 18XX74X	Course Title	Course code under 18XX74X	Course Title
18ME741	**Additive Manufacturing**	18ME744	**Mechatronics**
18ME742	**Emerging Sustainable Building Cooling Technologies**	18ME745	**Project Management**
18ME743	**Theory of Plasticity**		

Open Elective -B

Students can select any one of the open electives offered by other Departments expect those that are offered by the parent Department (Please refer to the list of open electives under 18XX75X).

Selection of an open elective shall not be allowed if,

- The candidate has studied the same course during the previous semesters of the programme.
- The syllabus content of open elective is similar to that of the Departmental core courses or professional electives.
- A similar course, under any category, is prescribed in the higher semesters of the programme.

Registration to electives shall be documented under the guidance of Programme Coordinator/ Advisor/Mentor.

Project work:

Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary project can be assigned to an individual student or to a group having not more than 4 students. In extraordinary cases, like the funded projects requiring students from different disciplines, the project student strength can be 5 or6.

CIE procedure for Project Work Phase - 1:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.

The CIE marks awarded for the project work phase -1, shall be based on the evaluation of the project work phase -1 Report (covering Literature Survey, Problem identification, Objectives and Methodology), project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the Project report shall be the same for all the batch mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, is desirable.

The CIE marks awarded for the project work phase -1, shall be based on the evaluation of project work phase -1 Report (covering Literature Survey, Problem identification, Objectives and Methodology), project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

Internship: All the students admitted to III year of BE/B. Tech shall have to undergo mandatory internship of 4 weeks during the vacation of VI and VII semesters and /or VII and VIII semesters. A University examination shall be conducted during VIII semester and the prescribed credit shall be included in VIII semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared fail and shall have to complete during subsequent University examination after satisfying the Internship requirements.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination 2018 – 19
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2018 – 19)

VIII SEMESTER

Sl. No	Course and Course code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	PCC	18ME81	**Energy Engineering**		3	--	--	03	40	60	100	3
2	PEC	18ME82X	**Professional Elective - 4**		3	--	--	03	40	60	100	3
3	Project	18MEP83	**Project Work Phase - 2**		--	--	2	03	40	60	100	8
4	Seminar	18MES84	**Technical Seminar**		--	--	2	03	100	--	100	1
5	Internship	18XXI85	Internship	Completed during the vacation/s of VI and VII semesters and /or VII and VIII semesters.)				03	40	60	100	3
				TOTAL	**06**	--	**04**	**15**	**260**	**240**	**500**	**18**

Note: PCC: Professional Core, PEC: Professional Elective.

Professional Electives - 4

Course code under 18XX82X	Course Title	Course code under 18XX82X	Course Title
18ME821	**CNC Machine Tools**	18ME824	**Automobile Engineering**
18ME822	**Tribology**	18ME825	**Tool Design**
18ME823	**Non-Destructive Testing and Evaluation**	18ME826	**Fracture Mechanics**

Project Work

CIE procedure for Project Work Phase - 2:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.

The CIE marks awarded for the project work phase -2, shall be based on the evaluation of project work phase -2 Report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, is desirable.

The CIE marks awarded for the project work phase -2, shall be based on the evaluation of project work phase -2 Report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

SEE for Project Work Phase - 2:

(i) Single discipline: Contribution to the project and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted at the department.

(ii) Interdisciplinary: Contribution to the project and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted separately at the departments to which the student/s belongs to.

Internship: Those, who have not pursued /completed the internship, shall be declared as fail and have to complete during subsequent University examination after satisfying the internship requirements.

AICTE activity Points: In case students fail to earn the prescribed activity Points, Eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of degree only after the release of the Eighth semester Grade Card.

Activity points of the students who have earned the prescribed AICTE activity Points shall be sent the University along with the CIE marks of 8th semester. In case of students who have not satisfied the AICTE activity Points at the end of eighth semester, the column under activity Points shall be marked NSAP (Not Satisfied Activity Points).

B.E. Mechanical Engineering

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

SEMESTER - VI

OPEN ELECTIVE - A

Course Code	18ME65X	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Students can select any one of the open electives offered by other Departments expect those that are offered by the parent Department (For syllabus, please refer to the concerned programme syllabus book or VTU website vtu.ac.in may be visited.).
Selection of an open elective shall not be allowed if,

- The candidate has studied the same course during the previous semesters of the programme.
- The syllabus content of open elective is similar to that of the Departmental core courses or professional electives.
- A similar course, under any category, is prescribed in the higher semesters of the programme.

Registration to electives shall be documented under the guidance of Programme Coordinator/ Advisor/Mentor.

Sl. No.	Board and the Department offering the Electives		Course Sl. No.	Course code under 18XX65X	Course Title
1	ME	Mechanical Engineering	1	18ME651	**Non-Conventional Energy Sources**
			2	18ME652	**World Class Manufacturing**
			3	18ME653	**Supply Chain Management**
			4	18ME654	**Advanced Materials Technology**

B.E Mechanical Engineering

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

SEMESTER - VII

OPEN ELECTIVE - B

Course Code	18ME75X	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Students can select any one of the open electives offered by other Departments expect those that are offered by the parent Department (For syllabus, please refer to the concerned programme syllabus book or VTU website vtu.ac.in may be visited.).
Selection of an open elective shall not be allowed if,

- The candidate has studied the same course during the previous semesters of the programme.
- The syllabus content of open elective is similar to that of the Departmental core courses or professional electives.
- A similar course, under any category, is prescribed in the higher semesters of the programme.

Registration to electives shall be documented under the guidance of Programme Coordinator/ Advisor/Mentor.

Sl NO	Board and the Department offering the Electives		Course Sl No	Course code under 18XX75X	Course Title
2	ME	Mechanical Engineering	1	18ME751	**Energy and Environment**
			2	18ME752	**Automotive Engineering**
			3	18ME753	**Industrial Safety**
			4	18ME754	**Optimization Techniques**

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

TRANSFORM CALCULUS, FOURIER SERIES AND NUMERICAL TECHNIQUES
(Common to all Programmes)

Course Code	**18MAT31**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:2:0)	SEE Marks	60
Credits	**03**	Exam Hours	03

Course Learning Objectives:

- To have an insight into Fourier series, Fourier transforms, Laplace transforms, Difference equations and Z-transforms.
- To develop the proficiency in variational calculus and solving ODE's arising in engineering applications, using numerical methods.

Module-1

Laplace Transforms: Definition and Laplace transform of elementary functions. Laplace transforms of Periodic functions and unit-step function – problems.
Inverse Laplace Transforms: Inverse Laplace transform - problems, Convolution theorem to find the inverse Laplace transform (without proof) and problems, solution of linear differential equations using Laplace transform.

Module-2

Fourier Series: Periodic functions, Dirichlet's condition. Fourier series of periodic functions period 2π and arbitrary period. Half range Fourier series. Practical harmonic analysis, examples from

Module-3

Fourier Transforms: Infinite Fourier transforms, Fourier sine and cosine transforms. Inverse Fourier transforms. Simple problems.
Difference Equations and Z-Transforms: Difference equations, basic definition, z-transform-definition, Standard z-transforms, Damping and shifting rules, initial value and final value theorems (without proof) and problems, Inverse z-transform. Simple problems.

Module-4

Numerical Solutions of Ordinary Differential Equations (ODE's): Numerical solution of ODE's of first order and first degree- Taylor's series method, Modified Euler's method. Range - Kutta method of fourth order, Milne's and Adam-Bashforth predictor and corrector method (No derivations of formulae), Problems.

Module-5

Numerical Solution of Second Order ODE's: Runge -Kutta method and Milne's predictor and corrector method.(No derivations of formulae).
Calculus of Variations: Variation of function and functional, variational problems, Euler's equation, Geodesics, hanging chain, problems.

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

- CO1: Use Laplace transform and inverse Laplace transform in solving differential/ integral equation arising in network analysis, control systems and other fields of engineering.
- CO2: Demonstrate Fourier series to study the behaviour of periodic functions and their applications in system communications, digital signal processing and field theory.
- CO3: Make use of Fourier transform and Z-transform to illustrate discrete/continuous function arising in wave and heat propagation, signals and systems.
- CO4: Solve first and second order ordinary differential equations arising in engineering problems using single step and multistep numerical methods.
- CO5:Determine the extremals of functionals using calculus of variations and solve problems arising in dynamics of rigid bodies and vibrational analysis.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Edition, 2016
2	Higher Engineering Mathematics	B. S. Grewal	Khanna Publishers	44th Edition, 2017
3	Engineering Mathematics	Srimanta Pal et al	Oxford University Press	3rd Edition, 2016
Reference Books				
1	Advanced Engineering Mathematics	C. Ray Wylie, Louis C. Barrett	McGraw-Hill Book Co	6th Edition, 1995
2	Introductory Methods of Numerical Analysis	S. S. Sastry	Prentice Hall of India	4th Edition 2010
3	Higher Engineering Mathematics	B.V. Ramana	McGraw-Hill	11th Edition,2010
4	A Text Book of Engineering Mathematics	N. P. Bali and Manish Goyal	Laxmi Publications	2014
5	Advanced Engineering Mathematics	Chandrika Prasad and Reena Garg	Khanna Publishing,	2018

Web links and Video Lectures:

1. http://nptel.ac.in/courses.php?disciplineID=111
2. http://www.class-central.com/subject/math(MOOCs)
3. http://academicearth.org/
4. VTU EDUSAT PROGRAMME - 20

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

MECHANICS OF MATERIALS

Course Code	**18ME32**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:2:0	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To know the different types of stresses and strains developed in the member subjected to axial, bending, shear, torsion & thermal loads.
- To know behaviour & properties of engineering materials.
- To understand the stresses developed in bars, compounds bars, beams, shafts, and cylinders.
- To understand the concepts of calculation of shear force and bending moment for beams with different supports.
- To expose the students to concepts of Buckling of columns and strain energy.

Module-1

Stresses and Strains: Introduction, Properties of materials, Stress, Strain and Hooke's law, Stress strain diagram for brittle and ductile materials, True stress and strain, Calculation of stresses in straight, Stepped and tapered sections, Composite sections, Stresses due to temperature change, Shear stress and strain, Lateral strain and Poisson's ratio, Elastic constants and relations between them.

Module-2

Analysis of Stress and Strain: Introduction to three dimensional state of stress, Stresses on inclined planes, Principal stresses and maximum shear stress, Principal angles, Shear stresses on principal planes, Maximum shear tress, Mohr circle for plane stress conditions.
Cylinders: Thin cylinder: Hoop's stress, maximum shear stress, circumferential and longitudinal strains, Thick cylinders: Lames equations.

Module-3

Shear Force and Bending Moment: Type of beams, Loads and reactions, Relationship between loads, shear forces and bending moments, Shear force and bending moments of cantilever beams, Pin support and roller supported beams subjected to concentrated loads, uniformly distributed constant / varying loads.
Stress in Beams: Bending and shear stress distribution in rectangular, I and T section beams.

Module-4

Theories of Failure: Maximum Principal stress theory, Maximum shear stress theory.
Torsion: Circular solid and hallow shafts, Torsional moment of resistance, Power transmission of straight and stepped shafts, Twist in shaft sections, Thin tubular sections, Thin walled sections.

Module-5

Columns: Buckling and stability, Critical load, Columns with pinned ends, Columns with other support conditions, Effective length of columns,
Secant formula for columns.
Strain Energy: Strain energy due to axial, shear, bending, torsion and impact load. Castigliano's theorem I and II and their applications.

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

- CO1: Understand simple, compound, thermal stresses and strains their relations and strain energy.
- CO2: Analyse structural members for stresses, strains and deformations.
- CO3: Analyse the structural members subjected to bending and shear loads.
- CO4: Analyse shafts subjected to twisting loads.
- CO5: Analyse the short columns for stability.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Mechanics of Materials	J M Gere, B J Goodno,	Cengage	Eighth edition 2013
2	Fundamentals of Strength of Materials	P N Chandramouli	PHI Learning Pvt. Ltd	2013
3	Strength of Materials	R K Rajput	S. Chand and Company Pvt. Ltd	2014
Reference Books				
1	Strength of Materials	R. Subramanian	Oxford	2005
2	Strength of Materials	S. S. Ratan	Tata McGraw Hill	2nd Edition, 2008
3	Mechanics of materials Strength of Materials	S C Pilli and N Balasubramanya	Cengage	2019
4	Mechanics of Materials	Ferdinand Beer, Russell Johston, John Dewolf, David Mazurek	McGraw Hill Education (India) Pvt. Ltd	Latest edition
5	Mechanics of Materials	R C Hibbeler	Pearson	Latest edition

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

BASIC THERMODYNAMICS

Course Code	**18ME33**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Learn about thermodynamic system and its equilibrium
- Understand various forms of energy - heat transfer and work
- Study the basic laws of thermodynamics including, zeroth law, first law and second law.
- Interpret the behaviour of pure substances and its application in practical problems.
- Study of Ideal and real gases and evaluation of thermodynamic properties

Module-1

Fundamental Concepts & Definitions: Thermodynamic definition and scope, Microscopic and Macroscopic approaches. Some practical applications of engineering thermodynamic Systems, Characteristics of system boundary and control surface, examples. Thermodynamic properties; definition and units, intensive, extensive properties, specific properties, pressure, specific volume, Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic; processes;
Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium, Zeroth law of thermodynamics, Temperature; concepts, scales, international fixed points and measurement of temperature. Constant volume gas thermometer, constant pressure gas thermometer, mercury in glass thermometer.

Module-2

Work and Heat: Mechanics, definition of work and its limitations. Thermodynamic definition of work; examples, sign convention. Displacement work; as a part of a system boundary, as a whole of a system boundary, expressions for displacement work in various processes through p-v diagrams. Shaft work; Electrical work. Other types of work. Heat; definition, units and sign convention. Problems.
First Law of Thermodynamics: Joules experiments, equivalence of heat and work. Statement of the First law of thermodynamics, extension of the First law to non - cyclic processes, energy, energy as a property, modes of energy, Extension of the First law to control volume; steady flow energy equation(SFEE), important

Module-3

Second Law of Thermodynamics: Limitations of first law of thermodynamics, Thermal reservoir, heat engine and heat pump: Schematic representation, efficiency and COP. Reversed heat engine, schematic representation, importance and superiority of a reversible heat engine and irreversible processes, internal and external reversibility. Kelvin - Planck statement of the Second law of Thermodynamics; PMM I and PMM II, Clausius statement of Second law of Thermodynamics, Equivalence of the two statements; Carnot cycle, Carnot principles. Problems
Entropy: Clausius inequality, Statement- proof, Entropy- definition, a property, change of entropy, entropy as a quantitative test for irreversibility, principle of increase in entropy, entropy as a coordinate.

Module-4

Availability, Irreversibility and General Thermodynamic relations. Introduction**,** Availability (Exergy), Unavailable energy, Relation between increase in unavailable energy and increase in entropy. Maximum work, maximum useful work for a system and control volume, irreversibility.
Pure Substances: P-T and P-V diagrams, triple point and critical points. Sub-cooled liquid, saturated liquid, mixture of saturated liquid and vapor, saturated vapor and superheated vapor states of pure substance with water as example. Enthalpy of change of phase (Latent heat). Dryness fraction (quality), T-S and H-S diagrams, representation of various processes on these diagrams. Steam tables and its use. Throttling calorimeter, separating and throttling calorimeter.

Module-5

Ideal gases: Ideal gas mixtures, Daltons law of partial pressures, Amagat's law of additive volumes, evaluation of properties of perfect and ideal gases, Air- Water mixtures and related properties.
Real gases – Introduction, Van-der Waal's Equation of state, Van-der Waal's constants in terms of critical properties, Beattie-Bridgeman equation, Law of corresponding states, compressibility factor; compressibility chart. Difference between Ideal and real gases.

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

- CO1: Explain fundamentals of thermodynamics and evaluate energy interactions across the boundary of thermodynamic systems.
- CO2: Evaluate the feasibility of cyclic and non-cyclic processes using 2nd law of thermodynamics.
- CO3: Apply the knowledge of entropy, reversibility and irreversibility to solve numerical problems and apply 1st law of thermodynamics to closed and open systems and determine quantity of energy transfers and change in properties.
- CO4: Interpret the behavior of pure substances and its application in practical problems.
- CO5: Recognize differences between ideal and real gases and evaluate thermodynamic properties of ideal and real gas mixtures using various relations.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Basic and Applied Thermodynamics	P.K.Nag,	Tata McGraw Hill	2nd Ed., 2002
2	Basic Engineering Thermodynamics	A.Venkatesh	Universities Press,	2008
3	Basic Thermodynamics,	B.K Venkanna, Swati B. Wadavadagi	PHI, New Delhi	2010
Reference Books				
3	Thermodynamics- An Engineering Approach	YunusA.Cenegal and Michael A.Boles	Tata McGraw Hill publications	2002
4	An Introduction to Thermodynamcis	Y.V.C.Rao	Wiley Eastern	1993,
5	Engineering Thermodynamics	.B.Jones and G.A.Hawkins	John Wiley and Sons.	

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

MATERIAL SCIENCE

Course Code	**18ME34**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- The foundation for understanding the structure and behaviour of materials common in mechanical engineering.
- Topics to explore the mechanical properties of metals and their alloys, polymers, ceramics, smart materials and composites.
- To understand modifications of material properties by heat treatment processes.
- Selections of different materials for various applications are highlighted.
- Impart knowledge of various failure modes of materials.

Module-1

Introduction to Crystal Structure: Coordination number, atomic packing factor, Simple Cubic, BCC,FCC and HCP Structures, Crystal imperfections–point, line, surface and volume imperfections. Atomic Diffusion: Phenomen on, Fick's laws of diffusion (First and Second Law);Factors affecting diffusion.

Mechanical Behaviour: Stress-strain diagrams showing ductile and brittle behaviour of materials, Engineering stress and true strains, Linear and non- linear elastic behaviour and properties, Mechanical properties in plastic range: Stiffness, Yield strength, Offset Yield strength, Ductility, Ultimate Tensile strength, Toughness. Plastic deformation of single crystal by slip and twinning, Mechanisms of strengthening in metals.

Module-2

Failure of Materials Fracture: Type I, Type II and Type III,

Fatigue: Types of fatigue loading with examples, Mechanism of fatigue, fatigue properties, S-N diagram, fatigue testing.

Creep: Description of the phenomenon with examples, three stages of creep, creep properties, Stress relaxation. Concept of fracture toughness, numerical on diffusion, strain and stress relaxation. Alloys, Steels, Solidification:

Conceptofformationofalloys:Typesofalloys,solidsolutions,factorsaffectingsolidsolubility(HumeRotheryrules) ,Binary phasediagrams:Eutectic,andEutectoidsystems,Leverrule,Intermediatephases,(The same type of process will study in Iron Carbon Phase Diagrams) Gibbs phase rule, Effect of non-equilibrium cooling, Coring and Homo genization Iron-Carbon (Cementite) diagram: description of phases, Effect of common alloying elements in steel, Common alloy steels, Stainless steel, Tool steel, Specifications of steels.

Solidification: Mechanism of solidification, Homogenous and Heterogeneous nucleation, Crystal growth,

Module-3

Heat Treatment, Ferrous and Non-Ferrous Alloys: Heat treating of metals: Time-Temperature-Transformation (TTT) curves, Continuous Cooling Transformation (CCT) curves, Annealing: Recovery, Re crystallization and Grain growth, Types of annealing, Normalizing, Hardening, Tempering, Mar tempering, Austempering, Concept of harden ability, Factors affecting harden ability.

Surface hardening methods: carburizing, cyaniding, nit riding, flame hardening and induction hardening, Age hardening of aluminium-copper alloys and PH steels. Ferrous materials: Properties, Compositions and uses of Grey cast iron and steel.

Module-4

Composite Materials : Composite materials - Definition, classification, types of matrix materials & reinforcements, Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs) and Polymer Matrix Composites (PMCs), Particulate-reinforced and fiber- reinforced composites, Fundamentals of production of composites, characterization of composites, constitutive relations of composites, determination of composite properties from component properties, hybrid composites. Applications of composite materials. Numerical on determining properties of composites.

Module-5

Other Materials, Material Selection

Ceramics: Structure type sand properties and applications of ceramics. Mechanical/ Electrical behaviour and processing of Ceramics.

Plastics: Various types of polymers/plastics and their applications. Mechanical behaviour and processing of plastics, Failure of plastics.

Other materials: Brief description of other materials such as optical and thermal materials.

Smart materials–fiber optic materials,piezo-electrics,shapememoryalloys–Nitinol,superelasticity.

Biological applications of smart materials-materials usedasim plants in human Body, selection of materials, performance of materials in service. Residual life assessment–use of non-destructive testing, economics, environment and Sustainability.

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

CO1: Understand the mechanical properties of metals and their alloys.

CO2: Analyze the various modes of failure and understand the microstructures of ferrous and non-ferrous materials.

CO3: Describe the processes of heat treatment of various alloys.

CO4: Acquire the Knowledge of composite materials and their production process as well as applications.

CO5: Understand the properties and potentialities of various materials available and material selection procedures.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Foundations of Materials Science and Engineering	Smith	McGrawHill	4thEdition, 2009.
2	Material science and Engineering and Introduction	WilliamD.Callister	Wiley	2006
3	Materials Science	Shackle ford., & M. K. Muralidhara	Pearson Publication	2007
Reference Books				
3	Materials Science and Engineering	V.Raghavan	PHI	2002
4	The Science and Engineering of Materials	Donald R. Askland and Pradeep.P. Phule	Cengage Learning	4lhEd., 2003
5	Mechanical Metallurgy	GeorgeEllwoodDieter	McGraw-Hill.	
6	ASM Handbooks	American Society of Metals		
7	Elements of Materials Science and Engineering	H. VanVlack,	Addison-Wesley Edn	1998
8	An introduction to Metallurgy	Alan Cottrell	University Press India	1974.

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

METAL CUTTING AND FORMING

Course Code	**18ME35A/45A**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To enrich the knowledge pertaining to relative motion and mechanics required for various machine tools.
- To introduce students to different machine tools to produce components having different shapes and sizes.
- To develop the knowledge on mechanics of machining process and effect of various parameters on machining.
- To acquaint with the basic knowledge on fundamentals of metal forming processes
- To study various metal forming processes.

Module-1

Introduction to Metal cutting: Orthogonal and oblique cutting. Classification of cutting tools: single, and multipoint; tool signature for single point cutting tool. Mechanics of orthogonal cutting; chip formation, shear angle and its significance, Merchant circle diagram. Numerical problems.
Cutting tool materials and applications.
Introduction to basic metal cutting machine tools: Lathe- Parts of lathe machine, accessories of lathe machine, and various operations carried out on lathe. Kinematics of lathe. Turret and Capstan lathe.

Module-2

Milling: Various Milling operations, classification of milling machines, Vertical & Horizontal milling, up milling & down milling. Indexing: need of indexing, simple, compound & differential indexing.
Drilling: Difference between drilling, boring & reaming, types of drilling machines. Boring operations & boring machines.
Shaping, Planing and Slotting machines-machining operations and operating parameters.
Grinding: Grinding operation, classification of grinding processes: cylindrical, surface &centerless grinding

Module-3

Introduction to tool wear, tool wear mechanisms, tool life equations, effect of process parameters on tool life, machinability. Cutting fluid-types and applications, surface finish, effect of machining parameters on surface finish. Economics of machining process, choice of cutting speed and feed, tool life for minimum cost and production time. Numerical problems.

Module-4

MECHANICAL WORKING OF METALS
Introduction to metal forming processes & classification of metal forming processes. Hot working & cold working of metals. Forging: Smith forging, drop forging & press forging. Forging Equipment, Defects in forging.
Rolling: Rolling process, Angle of bite, Types of rolling mills, Variables of rolling process, Rolling defects.
Drawing & Extrusion: Drawing of wires, rods & pipes, Variables of drawing process. Difference between drawing & extrusion. Various types of extrusion processes.

Module-5

Sheet Metal Operations: Blanking, piercing, punching, drawing, draw ratio, drawing force, variables in drawing, Trimming, and Shearing.
Bending — types of bending dies, Bending force calculation,
Embossing and coining.
Types of dies: Progressive, compound and combination dies.

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

CO1: Explain the construction & specification of various machine tools.

CO2: Discuss different cutting tool materials, tool nomenclature & surface finish.

CO3: Apply mechanics of machining process to evaluate machining time.

CO4: Analyze tool wear mechanisms and equations to enhance tool life and minimize machining cost.

CO5: Understand the concepts of different metal forming processes.

CO6: Apply the concepts of design of sheet metal dies to design different dies for simple sheet metal components.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Manufacturing Technology Vol I & II	P.N.Rao	Tata McGraw Hill Pub. Co. Ltd., New Delhi	1998
2	A textbook of Production Technology Vol I and II	Sharma, P.C.,	S. Chand & Company Ltd., New Delhi	1996
3	Manufacturing Science	Amithab Gosh &A.K.Malik	East-West press	2001
Reference Books				
3	Workshop Technology Vol. I and II	Chapman W. A. J.	Arnold Publisher New Delhi	1998
4	Elements of Manufacturing Technology Vol II,	Hajra Choudhary, S. K. and Hajra Choudhary, A. K.	Media Publishers, Bombay	1988
5	Metal Forming Handbook	Schuler	Springer Verlag Publication	
6	Metal Forming: Mechanics and Metallurgy	Hosford,WF and Caddell,R.M	Prentice Hall	1993
7	Manufacturing Engineering and Technology	Kalpakjian	Addision Wesley CongmenPvt. Ltd.	2000
8	Production Technology	HMT		

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

METAL CASTING AND WELDING

Course Code	**18ME35B/45B**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To provide adequate knowledge of quality test methods conducted on welded and cast components.
- To provide knowledge of various casting process in manufacturing.
- To provide in-depth knowledge on metallurgical aspects during solidification of metal and alloys.
- To provide detailed information about the moulding processes.
- To impart knowledge of various joining process used in manufacturing.
- To impart knowledge about behaviour of materials during welding, and the effect of process parameters in welding,

Module-1

Introduction & basic materials used in foundry:
Introduction: Definition, Classification of manufacturing processes. Metals cast in the foundry-classification, factors that determine the selection of a casting alloy.
Introduction to casting process & steps involved:
Patterns: Definition, classification, materials used for pattern, various pattern allowances and their importance.
Sand moulding: Types of base sand, requirement of base sand. Binder, Additives definition, need and types; preparation of sand moulds. Melding machines- Jolt type, squeeze type and Sand slinger.
Study of important moulding process: Green sand, core sand, dry sand, sweep mould, CO_2mould, shell mould, investment mould, plaster mould, cement bonded mould.
Cores: Definition, need, types. Method of making cores,
Concept of gating (top, bottom, parting line, horn gate) and risers (open, blind) Functions and types.

Module-2

MELTING & METAL MOLD CASTING METHODS
Melting furnaces: Classification of furnaces, Gas fired pit furnace, Resistance furnace, Coreless induction furnace, electric arc furnace, constructional features & working principle of cupola furnace.
Casting using metal moulds: Gravity die casting, pressure die casting, centrifugal casting, squeeze casting, slush casting, thixocasting, and continuous casting processes.

Module-3

SOLIDIFICATION &NON-FERROUS FOUNDRY PRACTICE
Solidification: Definition, nucleation, solidification variables. Directional solidification-need and methods. Degasification in liquid metals-sources of gas, degasification methods.
Fettling and cleaning of castings: Basic steps involved. Sand Casting defects- causes, features and remedies. Advantages & limitations of casting process
Nonferrous foundry practice: Aluminium castings - advantages, limitations, melting of Aluminium using lift-out type crucible furnace. Hardeners used, drowsing, gas absorption, fluxing and flushing, grain refining, pouring temperature. Stir casting set up, procedure, uses, advantages and limitations.

Module-4

Welding process: Definition, Principles, classification, application, advantages & limitations of welding. Arc welding: Principle, Metal arc welding (MAW), Flux Shielded Metal Arc Welding (FSMAW), Inert Gas Welding (TIG & MIG) Submerged Arc Welding (SAW) and Atomic Hydrogen Welding (AHW).
Special type of welding: Resistance welding principles, Seam welding, Butt welding, Spot welding and Projection welding. Friction welding, Explosive welding, Thermit welding, Laser welding and Electron beam welding.

Module-5

METALLURGICAL ASPECTS IN WELDING, SOLDERING, AND BRAZING

Structure of welds, Formation of different zones during welding, Heat Affected Zone (HAZ), Parameters affecting HAZ. Effect of carbon content on structure and properties of steel, Shrinkage in welds& Residual stresses. Concept of electrodes, filler rod and fluxes. Welding defects- detection, causes & remedy.

Soldering, brazing, gas welding: Soldering, Brazing, Gas Welding: Principle, oxy-Acetylene welding, oxy-hydrogen welding, air-acetylene welding, Gas cutting, powder cutting.

Inspection methods: Methods used for inspection of casting and welding. Visual, magnetic particle, fluorescent particle, ultrasonic. Radiography, eddy current, holography methods of inspection.

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

CO1: Describe the casting process and prepare different types of cast products.

CO2: Acquire knowledge on Pattern, Core, Gating, Riser system and to use Jolt, Squeeze, Sand Slinger Moulding machines.

CO3: Compare the Gas fired pit, Resistance, Coreless, Electrical and Cupola Metal Furnaces.

CO4: Compare the Gravity, Pressure die, Centrifugal, Squeeze, slush and Continuous Metal mold castings.

CO5: Understand the Solidification process and Casting of Non-Ferrous Metals.

CO6: Describe the Metal Arc, TIG, MIG, Submerged and Atomic Hydrogen Welding processes etc. used in manufacturing.

CO7: Describe methods for the quality assurance of components made of casting and joining process

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Principles of metal casting	Rechard W. Heine, Carl R. Loper Jr., Philip C. Rosenthal	Tata McGraw Hill Education Private Limited	1976
2	Manufacturing Process-I	Dr.K.Radhakrishna	Sapna Book House,	5th Revised Edition 2009.
3	Manufacturing Technology-Foundry, Forming and	P.N.Rao	Tata McGraw Hill	3rd Ed., 2003.
Reference Books				
4	Process and Materials of Manufacturing	Roy A Lindberg	Pearson Edu	4th Ed. 2006
5	Manufacturing Technology	Serope Kalpakjian Steuen. R Sechmid	Pearson Education Asia	5th Ed. 2006

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

COMPUTER AIDED MACHINE DRAWING

Course Code	**18ME36A/46A**	CIE Marks	40
Teaching Hours/Week (L:T:P)	1:4:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To acquire the knowledge of CAD software and its features.
- To familiarize the students with Indian Standards on drawing practices.
- To impart knowledge of thread forms, fasteners, keys, joints and couplings.
- To make the students understand and interpret drawings of machine components leading to preparation of assembly drawings manually and using CAD packages.
- To acquire the knowledge of limits, tolerance and fits and indicate them on machine drawings.

Part A

Part A

Introduction:
Review of graphic interface of the software. Review of basic sketching commands and navigational commands. Starting a new drawing sheet. Sheet sizes. Naming a drawing, Drawing units, grid and snap. Conversion of pictorial views into orthographic projections of simple machine parts (with and without section). Hidden line conventions. Precedence of lines.
Sections of Solids: Sections of Pyramids, Prisms, Cubes, Tetrahedrons, Cones and Cylinders resting only on their bases (No problems on axis inclinations, spheres and hollow solids). True shape of sections.
Conversion of pictorial views into orthographic projections of simple machine parts. Hidden line conventions. Precedence of lines.
Conversion of pictorial views into orthographic projections of simple machine parts (with section planes indicated on the part).
Thread Forms: Thread terminology, sectional views of threads. ISO Metric (Internal & External), BSW (Internal & External) square and Acme. Sellers thread, American Standard thread.
Fasteners: Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly) simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, counter sunk head screw, grub screw, Allen screw.

Part B

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

Part C

Limits, Fits and Tolerances: Introduction, Fundamental tolerances, Deviations, Methods of placing limit dimensions, machining symbols, types of fits with symbols and applications, geometrical tolerances on drawings. Standards followed in industry.
Assembly Drawings: (Part drawings shall be given)
1. Plummer block (Pedestal Bearing)
2. Lever Safety Valve
3. I.C. Engine connecting rod
4. Screw jack (Bottle type)
5. Tailstock of lathe
6. Machine vice
7. Tool head of shaper

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

CO1: Identify the national and international standards pertaining to machine drawing.

CO2: Understand the importance of the linking functional and visualization aspects in the preparation of the part drawings

CO3: Apply limits and tolerances to assemblies and choose appropriate fits for given assemblies.

CO4: Interpret the Machining and surface finish symbols on the component drawings.

CO5: Preparation of the part or assembly drawings as per the conventions.

Scheme of Examination: Two questions to be set from each Part A, part B and Part C. Student has to answer one question each from Part A and Part B for 25 marks each and one question from Part C for 50 marks.

INSTRUCTION FOR COMPUTER AIDED MACHINE DRAWING (15ME36A/46A) EXAMINATION

1. No restriction of timing for sketching/ computerization of solutions. The total duration is 3 hours.
2. It is desirable to do sketching of all the solutions before computerization.
3. Drawing instruments may be used for sketching.
4. For Part A and Part B, 2D drafting environment should be used.
5. For Part C, 3D environment should be used for parts and assembly, and extract 2D views of assembly.
6. Part A and Part B
   25 Marks (15 marks for sketching and 10 marks for computer work)
7. Part C
   50 Marks (20 marks for sketching and 30 marks for computer modelling)

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Machine Drawing	K.R. Gopala Krishna	Subhash Publication	2005
2	Machine Drawing	N.D.Bhat&V.M. Panchal	Charoratar publishing house	2005
Reference Books				
3	A Text Book of Computer Aided Machine Drawing	S. Trymbaka Murthy	CBS Publishers, New Delhi	2007
4	Engineering drawing	P.S.Gill	S K Kataria and Sons	2013
5	Machine Drawing	N. Siddeshwar, P. Kanniah, V.V.S. Sastri	Tata McGraw Hill	2006

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

MECHANICAL MEASUREMENTS AND METROLOGY

Course Code	**18ME36B/46B**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the concept of metrology and standards of measurement.
- To equip with knowledge of limits, fits, tolerances and gauging
- To acquire knowledge of linear and Angular measurements, Screw thread and gear measurement & comparators.
- To understand the knowledge of measurement systems and methods with emphasis on different Transducers, intermediate modifying and terminating devices.
- To understand the measurement of Force, Torque, Pressure, Temperature and Strain.

Module-1

Introduction to Metrology: Definition, objectives of metrology, Material Standards, Wavelength Standards, Classification of standards, Line and End standards, Calibration of End bars. Numerical examples.
Liner measurement and angular measurements: Slip gauges-Indian standards on slip gauges, Adjustable slip gauges, Wringing of slip gauges, Problems on building of slip gauges (M87, M112), Measurement of angle-sine bar, Sine centre, Angle gauges, Optical instruments for angular measurements. Autocollimator-Applications for measuring straightness and squareness.

Module-2

System of Limits, Fits, Tolerance and Gauging: Definitions, Tolerance, Tolerance analysis (addition & subtraction of tolerances) Inter changeability & Selective assembly. Class &grade of tolerance, Fits, Types of fits, Numerical on limits, fit and tolerance. Hole base system & shaft base system. Taylor's principle, Types of limit gauges, Numerical on limit gauge design.
Comparators: Functional requirements, Classification, Mechanical- Johnson Mikrokator, Sigma comparators, Dial indicator, Electrical comparators, LVDT, Pneumatic comparators- Principle of back pressure, Solex comparators, Optical comparators, Zeiss ultraoptimeter.

Module-3

Measurement of screw thread and gear: Terminology of screw threads, Measurement of major diameter, Minor diameter, Pitch, Angle and Effective diameter of screw threads by 2- wire and 3-wire methods, Best size wire. Screw thread gauges, Toolmaker's microscope.
Gear tooth Measurements: Tooth thickness measurement using constant chord method, Addendum, Comparator method and Base tangent method, Measurement of pitch, Concentricity, Run out and In volute profile. Gear roll tester for composite error.

Module-4

Measurement system and basic concepts of measurement methods: Definition, Significance of measurement, Generalized measurement system, Static characteristics- Accuracy, Precision, Calibration, Threshold, Sensitivity, Hysteresis, Repeatability, Linearity, Loading effect, Dynamic characteristics- System response, Time delay. Errors in measurement, Classification of errors.

Transducers: Transfer efficiency, Primary and Secondary transducers, Electrical transducers, Mechanical, Electronic transducers, Relative comparison of each type of transducers.
Intermediate Modifying and Terminating Devices: Mechanical systems, Inherent problems, Electrical intermediate modifying devices, Input circuitry, Ballast circuit, Electronic amplifiers. Terminating devices, Cathode ray oscilloscope, Oscillographs.

Module-5

Applied mechanical measurement: Measurement of force, Torque, Pressure, Types of Dynamometers, Absorption dynamometer, Prony brake and Rope brake dynamometer, and Power Measuring Instruments. Use of elastic members, Bridgeman gauge, McLeod gauge, Pirani gauge.

Measurement of strain and temperature: Theory of strain gauges, Types, Electrical resistance strain gauge, Preparation and mounting of Strain gauges, Gauge factor, Methods of strain measurement, temperature compensation, Resistance thermometers, Thermocouple, Law of thermocouple, Pyrometer, Optical pyrometer.

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

CO1: Understand the objectives of metrology, methods of measurement, standards of measurement & various measurement parameters.

CO2: Explain tolerance, limits of size, fits, geometric and position tolerances, gauges and their design

CO3: Understand the working principle of different types of comparators.

CO3: Describe measurement of major & minor diameter, pitch, angle and effective diameter of screw threads.

CO4: Explain measurement systems, transducers, intermediate modifying devices and terminating devices..

CO5: Describe functioning of force, torque, pressure, strain and temperature measuring devices.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Mechanical Measurements	Beckwith Marangoni and Lienhard	Pearson Education	6th Ed., 2006
2	Instrumentation, Measurement and Analysis	B C Nakra, K K Chaudhry	McGraw–Hill	4th Edition
3	Engineering Metrology	R.K. Jain	Khanna Publishers	2009
Reference Books				
1	Engineering Metrology and Measurements	Bentley	Pearson Education	
2	Theory and Design for Mechanical Measurements, III edition	Richard S Figliola, Donald E Beasley	WILEY India Publishers	
3	Engineering Metrology	Gupta I.C	Dhanpat Rai Publications	
4	Deoblin's Measurement system,	Ernest Deoblin, Dhanesh manick	McGraw–Hill	
5	Engineering Metrologyand Measurements	N.V.Raghavendra and L. Krishnamurthy	Oxford University Press.	

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – III

MATERIAL TESTING LAB

Course Code	**18MEL37A/47A**	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To learn the concept of the preparation of samples to perform characterization such as microstructure, volume fraction of phases and grain size.
- To understand mechanical behaviour of various engineering materials by conducting standard tests.
- To learn material failure modes and the different loads causing failure.
- To learn the concepts of improving the mechanical properties of materials by different methods like heat treatment, surface treatment etc.

Sl. No.	Experiments
	PART A
1	Preparation of specimen for Metallographic examination of different engineering materials. To report microstructures of plain carbon steel, tool steel, gray C.I, SG iron, Brass, Bronze & composites.
2	Heat treatment: Annealing, normalizing, hardening and tempering of steel. Metallographic specimens of heat treated components to be supplied and students should report microstructures of furnace cooled, water cooled, air cooled, tempered steel. Students should be able to distinguish the phase changes in a heat treated specimen compared to untreated specimen.
3	Brinell, Rockwell and Vickers's Hardness tests on untreated and heat treated specimens.
4	To study the defects of Cast and Welded components using Non-destructive tests like: a) Ultrasonic flaw detection b) Magnetic crack detection c) Dye penetration testing.
	PART B
5	Tensile, shear and compression tests of steel, aluminum and cast iron specimens using Universal Testing Machine
6	Torsion Test on steel bar.
7	Bending Test on steel and wood specimens.
8	Izod and Charpy Tests on Mild steel and C.I Specimen.
9	To study the wear characteristics of ferrous and non-ferrous materials under different parameters.
10	Tensile, shear and compression tests of steel, aluminum and cast iron specimens using Universal Testing Machine
11	Fatigue Test (demonstration only).

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

CO1: Acquire experimentation skills in the field of material testing.

CO2: Develop theoretical understanding of the mechanical properties of materials by performing experiments.

CO3: Apply the knowledge to analyse a material failure and determine the failure inducing agent/s.

CO4: Apply the knowledge of testing methods in related areas.

CO5: Understand how to improve structure/behaviour of materials for various industrial applications.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.

Scheme of Examination:

ONE question from part -A:	30 Marks
ONE question from part -B:	50 Marks
Viva -Voice:	20 Marks
Total:	100 Marks

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – III

MECHANICAL MEASUREMENTS AND METROLOGY LAB

Course Code	**18MEL37B/47B**	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To illustrate the theoretical concepts taught in Mechanical Measurements & Metrology through experiments.
- To illustrate the use of various measuring tools & measuring techniques.
- To understand calibration techniques of various measuring devices.

Sl. No.	Experiments
	PART A
1	Calibration of Pressure Gauge
2	Calibration of Thermocouple
3	Calibration of LVDT
4	Calibration of Load cell
5	Determination of modulus of elasticity of a mild steel specimen using straingauges.
	PART B
6	Measurements using Optical Projector / Tool makers' Microscope.
7	Measurement of angle using Sine Centre / Sine bar / bevelprotractor
8	Measurement of alignment using Autocollimator / Rollerset
9	Measurement of cutting tool for cesusing:
10	Measurements of Screw thread parameters using two wire or three-wire methods.
11	Measurements of surface roughness using Tally Surf/Mechanical Comparator
12	Measurement of gear tooth profile using gear tooth Vernier/Gear tooth micrometer
13	Calibration of Micrometer using slip gauges
14	Measurement using Optical Flats

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

CO1: Understand Calibration of pressure gauge, thermocouple, LVDT, load cell, micrometre.

CO2: Apply concepts of Measurement of angle using Sine Centre/ Sine Bar/ Bevel Protractor, alignment using Autocollimator/ Roller set.

CO3: Demonstrate measurements using Optical Projector/Tool maker microscope, Optical flats.

CO4: Analyse tool forces using Lathe/Drill tool dynamometer.

CO5: Analyse Screw thread parameters using 2-Wire or 3-Wire method, gear tooth profile using gear tooth Vernier/Gear tooth micrometre

CO6: Understand the concepts of measurement of surface roughness.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.

Scheme of Examination:

ONE question from part -A: 30 Marks
ONE question from part -B: 50 Marks
Viva -Voice: 20 Marks
Total: 100 Marks

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – III

WORKSHOP AND MACHINE SHOP PRACTICE

Course Code	**18MEL38A/48A**	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To guide students to use fitting tools to perform fitting operations.
- To provide an insight to different machine tools, accessories and attachments.
- To train students into fitting and machining operations to enrich their practical skills.
- To inculcate team qualities and expose students to shop floor activities.
- To educate students about ethical, environmental and safety standards.

	Experiments
Sl. No	**PART A**
1	Preparation of at least two fitting joint models by proficient handling and application of hand tools- V-block, marking gauge, files, hack saw drills etc.
	PART B
2	Preparation of three models on lathe involving - Plain turning, Taper turning, Step turning, Thread cutting, Facing, Knurling, Drilling, Boring, Internal Thread cutting and Eccentric turning. Exercises should include selection of cutting parameters and cutting time estimation.
	PART C
3	Cutting of V Groove/ dovetail / Rectangular groove using a shaper. Cutting of Gear Teeth using Milling Machine. Exercises should include selection of cutting parameters and cutting time estimation.
	PART D (DEMONSTRATION ONLY)
	Study & Demonstration of power tools like power drill, power hacksaw, portable hand grinding, cordless screw drivers, production air tools, wood cutter, etc., used in Mechanical Engineering.

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

CO1: To read working drawings, understand operational symbols and execute machining operations.
CO2: Prepare fitting models according to drawings using hand tools- V-block, marking gauge, files, hack saw, drills etc.
CO3: Understand integral parts of lathe, shaping and milling machines and various accessories and attachments used.
CO4: Select cutting parameters like cutting speed, feed, depth of cut, and tooling for various machining operations.
CO5: Perform cylindrical turning operations such as plain turning, taper turning, step turning, thread Cutting, facing, knurling, internal thread cutting, eccentric turning and estimate cutting time.
CO6:Perform machining operations such as plain shaping, inclined shaping, keyway cutting, Indexing and

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Scheme of Examination:	
One Model from Part-A or Part-C:	30 Marks
One Model from Part-B:	50 Marks
Viva – Voce:	20 Marks
TOTAL:	100 Marks

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – III

FOUNDRY, FORGING AND WELDING LAB

Course Code	**18MEL38B/48B**	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To provide an insight into different sand preparation and foundry equipment.
- To provide an insight into different forging tools and equipment and arc welding tools and equipment.
- To provide training to students to enhance their practical skills in welding, forging and hand moulding.

Sl. No	Experiments
	PART A
1	**Testing of Molding sand and Core sand.** **Preparation of sand specimens and conduction of the following tests:** 1. Compression, Shear and Tensile tests on Universal Sand Testing Machine. 2. Permeability test 3. Sieve Analysis to find Grain Fineness Number (GFN) of Base Sand 4. Clay content determination on Base Sand. **Welding Practice:** Use of Arc welding tools and welding equipment Preparation of welded joints using Arc Welding equipment L-Joint, T-Joint, Butt joint, V-Joint, Lap joints on M.S. flats
	PART B
2	**Foundry Practice:** **Use of foundry tools and other equipment for Preparation of molding sand mixture.** **Preparation of green sand molds kept ready for pouring in the following cases:** 1. Using two molding boxes (hand cut molds). 2. Using patterns (Single piece pattern and Split pattern). 3. Incorporating core in the mold.(Core boxes). 4. Preparation of one casting (Aluminium or cast iron-Demonstration only)
	PART C
3	**Forging Operations:** Use of forging tools and other forging equipment. • Calculation of length of the raw material required to prepare the model considering scale loss. • Preparing minimum three forged models involving upsetting, drawing and bending operations.

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

- Demonstrate various skills in preparation of molding sand for conducting tensile, shear and compression tests using Universal sand testing machine.
- Demonstrate skills in determining permeability, clay content and Grain Fineness Number of base sands.
- Demonstrate skills in preparation of forging models involving upsetting, drawing and bending operations.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Updated on 16.04.2020/28092020

Scheme of Examination:

1. One question is to be set from Part-A : 30 marks
   (20 marks for sand testing+ 10 Marks for welding)
2. One question is to be set from either Part-B or Part-C: 50 Marks
3. Viva – Voce: 20 marks

ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ
ಸಾಂಸ್ಕೃತಿಕ ಕನ್ನಡ ಪಠ್ಯಪುಸ್ತಕ

(ಕನ್ನಡ ಮಾತೃಭಾಷೆಯ ವಿದ್ಯಾರ್ಥಿಗಳಿಗೆ)

(ಕನ್ನಡಿಗರಿಗಾಗಿ – for Kannadigas - Common to all branches)

[As per Outcome Based Education (OBE) and Choice Based Credit System (CBCS) scheme]

ಸಾಂಸ್ಕೃತಿಕ ಕನ್ನಡ ಕಲಿಕೆಯ ಉದ್ದೇಶಗಳು:

- ಪದವಿ ವಿದ್ಯಾರ್ಥಿಗಳಾಗಿರುವುದರಿಂದ ಸಾಂಸ್ಕೃತಿಕ ಕನ್ನಡದ ಜೊತೆಗೆ ಕ್ರಿಯಾತ್ಮಕ ಕನ್ನಡವನ್ನು, ಕನ್ನಡ ಸಾಹಿತ್ಯ, ಸಂಸ್ಕೃತಿ ಮತ್ತು ನಾಡು ನುಡಿಯ ಪರಿಚಯ ಮಾಡಿಕೊಡುವುದು.
- ಕನ್ನಡದಲ್ಲಿ ತಾಂತ್ರಿಕ ವಿಜ್ಞಾನಗಳ ವಿಷಯಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಹಲವಾರು ವಿಷಯಗಳನ್ನು ಪರಿಚಯ ಮಾಡಿಕೊಡುವುದು.
- ಕನ್ನಡ ಭಾಷಾಭ್ಯಾಸ, ಸಾಮಾನ್ಯ ಕನ್ನಡ ಹಾಗೂ ಆಡಳಿತ ಕನ್ನಡದ ಪದಗಳ ಪರಿಚಯ ಮಾಡಿಕೊಡುವುದು.

ಪರಿವಿಡಿ

---

* **(ಅಧ್ಯಾಯ 3, 19, 20 ಮತ್ತು 21 ಇವುಗಳು** ವಿತಾವಿ ಯದಿಂದ ಪ್ರಕಟಿತ **" ಆಡಳಿತ ಕನ್ನಡ "** ಪುಸ್ತಕದಿಂದ ಆಯ್ದ ಲೇಖನಗಳು – **ಡಾ. ಎಲ್. ತಿಮ್ಮೇಶ** ಮತ್ತು **ಪ್ರೊ. ವಿ. ಕೇಶವಮೂರ್ತಿ.**

ಸಂಪಾದಕರು

ಡಾ. ಹಿ. ಚಿ. ಬೋರಲಿಂಗಯ್ಯ
ವಿಶ್ರಾಂತ ಕುಲಪತಿಗಳು, ಕನ್ನಡ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಹಂಪಿ.

ಡಾ. ಎಲ್. ತಿಮ್ಮೇಶ
ಸಹಾಯಕ ಪ್ರಾಧ್ಯಾಪಕರು ಮತ್ತು ಮುಖ್ಯಸ್ಥರು,
ಮಾನವಿಕ ಮತ್ತು ಸಾಮಾಜಿಕ ವಿಜ್ಞಾನಗಳ ವಿಭಾಗ,
ಸರ್ಕಾರಿ ಇಂಜಿನಿಯರಿಂಗ್ ಕಾಲೇಜು, ಹಾಸನ.

ಪ್ರಕಟಣೆ

ಪ್ರಸಾರಾಂಗ, ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಬೆಳಗಾವಿ.

2020

ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ

ಕನ್ನಡೇತರರಿಗೆ ಕನ್ನಡ ಕಲಿಸಲು ಗೊತ್ತುಪಡಿಸಿದ ಪಠ್ಯಪುಸ್ತಕ

ಬಳಕೆ ಕನ್ನಡ - baLake Kannada (Kannada for Usage)

(Common to B.Arch, B.Plan and B.E/B.Tech of all branches)

[As per Outcome Based Education (OBE) and Choice Based Credit System (CBCS) scheme]

Course Learning Objectives:

The course will enable the non Kannadiga students to understand, speak, read and write Kannada language and communicate (converse) in Kannada language in their daily life with kannada speakers.

Table of Contents

Part – I Lessons to teach and Learn Kannada Language

ಲೇಖಕರು

ಡಾ. ಎಲ್. ತಿಮ್ಮೇಶ

ಸಹಾಯಕ ಪ್ರಾಧ್ಯಾಪಕರು ಮತ್ತು ಮುಖ್ಯಸ್ಥರು
ಮಾನವಿಕ ಮತ್ತು ಸಾಮಾಜಿಕ ವಿಜ್ಞಾನಗಳ ವಿಭಾಗ
ಸರ್ಕಾರಿ ಇಂಜಿನಿಯರಿಂಗ್ ಕಾಲೇಜು - ಹಾಸನ

ಪ್ರಕಟಣೆ

ಪ್ರಸಾರಾಂಗ, ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಬೆಳಗಾವಿ.

2020

B. E. MECHANICAL ENGINEERING Outcome Based Education (OBE) and Choice Based Credit System (CBCS) SEMESTER - III			
CONSTITUTION OF INDIA, PROFESSIONAL ETHICS AND CYBER LAW (CPC)			
Course Code	**18CPC39/49**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:0)	SEE Marks	60
Credits	01	Exam Hours	02

Course Learning Objectives: To

- know the fundamental political codes, structure, procedures, powers, and duties of Indian government institutions, fundamental rights, directive principles, and the duties of citizens
- Understand engineering ethics and their responsibilities; identify their individual roles and ethical responsibilities towards society.
- Know about the cybercrimes and cyber laws for cyber safety measures.

Module-1

Introduction to Indian Constitution: The Necessity of the Constitution, The Societies before and after the Constitution adoption. Introduction to the Indian constitution, The Making of the Constitution, The Role of the Constituent Assembly - Preamble and Salient features of the Constitution of India. Fundamental Rights and its Restriction and limitations in different Complex Situations. Directive Principles of State Policy (DPSP) and its present relevance in our society with examples. Fundamental Duties and its Scope and significance in Nation building.

Module-2

Union Executive and State Executive: Parliamentary System, Federal System, Centre-State Relations. Union Executive – President, Prime Minister, Union Cabinet, Parliament - LS and RS, Parliamentary Committees, Important Parliamentary Terminologies. Supreme Court of India, Judicial Reviews and Judicial Activism. State Executives – Governor, Chief Minister, State Cabinet, State Legislature, High Court and Subordinate Courts, Special Provisions (Articles 370.371,371J) for some States.

Module-3

Elections, Amendments and Emergency Provisions: Elections, Electoral Process, and Election Commission of India, Election Laws. Amendments - Methods in Constitutional Amendments (How and Why) and Important Constitutional Amendments. Amendments – 7,9,10,12,42,44, 61, 73,74, ,75, 86, and 91,94,95,100,101,118 and some important Case Studies. Emergency Provisions, types of Emergencies and its consequences.

Constitutional special provisions: Special Provisions for SC and ST, OBC, Women, Children and Backward Classes.

Module-4

Professional / Engineering Ethics: Scope & Aims of Engineering & Professional Ethics - Business Ethics, Corporate Ethics, Personal Ethics. Engineering and Professionalism, Positive and Negative Faces of Engineering Ethics, Code of Ethics as defined in the website of Institution of Engineers (India): Profession, Professionalism, and Professional Responsibility. Clash of Ethics, Conflicts of Interest. Responsibilities in Engineering Responsibilities in Engineering and Engineering Standards, the impediments to Responsibility. Trust and Reliability in Engineering, IPRs (Intellectual Property Rights), Risks, Safety and liability in Engineering

Module-5

Internet Laws, Cyber Crimes and Cyber Laws: Internet and Need for Cyber Laws, Modes of Regulation of Internet, Types of cyber terror capability, Net neutrality, Types of Cyber Crimes, India and cyber law, Cyber Crimes and the information Technology Act 2000, Internet Censorship. Cybercrimes and enforcement agencies.

Course Outcomes: On completion of this course, students will be able to,

- CO1: Have constitutional knowledge and legal literacy.
- CO2: Understand Engineering and Professional ethics and responsibilities of Engineers.
- CO3: Understand the the cybercrimes and cyber laws for cyber safety measures.

Question paper pattern for SEE and CIE:

- The SEE question paper will be set for 100 marks and the marks scored by the students will proportionately be reduced to 60. The pattern of the question paper will be objective type (MCQ).
- For the award of 40 CIE marks, refer the University regulations 2018.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Constitution of India, Professional Ethics and Human Rights	Shubham Singles, Charles E. Haries, and et al	Cengage Learning India	2018
2	Cyber Security and Cyber Laws	Alfred Basta and et al	Cengage Learning India	2018
Reference Books				
3	Introduction to the Constitution of India	Durga Das Basu	Prentice –Hall,	2008.
4	Engineering Ethics	M. Govindarajan, S. Natarajan, V. S. Senthilkumar	Prentice –Hall,	2004

B. E. MECHANICAL ENGINEERING
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER - III

ADDITIONAL MATHEMATICS – I
(Mandatory Learning Course: Common to All Programmes)
(A Bridge course for Lateral Entry students under Diploma quota to BE/B. Tech. programmes)

Course Code	**18MATDIP31**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:1:0)	SEE Marks	60
Credits	0	Exam Hours	03

Course Learning Objectives:

- To provide basic concepts of complex trigonometry, vector algebra, differential and integral calculus.
- To provide an insight into vector differentiation and first order ODE's.

Module-1

Complex Trigonometry: Complex Numbers: Definitions and properties. Modulus and amplitude of a complex number, Argand's diagram, De-Moivre's theorem (without proof).
Vector Algebra: Scalar and vectors. Addition and subtraction and multiplication of vectors- Dot and Cross products, problems.

Module-2

Differential Calculus: Review of elementary differential calculus. Polar curves –angle between the radius vector and the tangent pedal equation- Problems. Maclaurin's series expansions, problems.
Partial Differentiation: Euler's theorem for homogeneous functions of two variables. Total derivatives - differentiation of composite function. Application to Jacobians of order two.

Module-3

Vector Differentiation: Differentiation of vector functions. Velocity and acceleration of a particle moving on a space curve. Scalar and vector point functions. Gradient, Divergence, Curl and Laplacian (Definitions only). Solenoidal and irrotational vector fields-Problems.

Module-4

Integral Calculus: Review of elementary integral calculus. Statement of reduction formulae for $\sin^n x, \cos^n x, and\ \sin^m x \times \cos^n x$and evaluation of these with standard limits-Examples. Double and triple integrals, problems.

Module-5

Ordinary differential equations (ODE's): Introduction-solutions of first order and first degree differential equations: Variable Separable methods, exact and linear differential equations of order one. Application to Newton's law of cooling.

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

- CO1: Apply concepts of complex numbers and vector algebra to analyze the problems arising in related area.
- CO2: Use derivatives and partial derivatives to calculate rate of change of multivariate functions.
- CO3: Analyze position, velocity and acceleration in two and three dimensions of vector valued functions. CO4: Learn techniques of integration including the evaluation of double and triple integrals.
- CO5: Identify and solve first order ordinary differential equations.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Higher Engineering Mathematics	B.S. Grewal	Khanna Publishers	43rd Edition, 2015

Reference Books				
1	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Edition, 2015
2	Engineering Mathematics Vol.I	RohitKhurana	Cengage Learning	2015

B. E. MECHANICAL ENGINEERING
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER - IV

COMPLEX ANALYSIS, PROBABILITY AND STATISTICAL METHODS
(Common to all programmes)
[As per Choice Based Credit System (CBCS) scheme]

Course Code	**18MAT41**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:2:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To provide an insight into applications of complex variables, conformal mapping and special functions arising in potential theory, quantum mechanics, heat conduction and field theory.
- To develop probability distribution of discrete, continuous random variables and joint probability distribution occurring in digital signal processing, design engineering and microwave engineering.

Module-1

Calculus of complex functions: Review of function of a complex variable, limits, continuity, and differentiability. Analytic functions: Cauchy-Riemann equations in Cartesian and polar forms and consequences.
Construction of analytic functions: Milne-Thomson method-Problems.

Module-2

Conformal transformations: Introduction. Discussion of transformations:$w = Z^2, w = e^z, w = z + \frac{1}{z}, (z \neq 0)$.Bilinear transformations- Problems.
Complex integration: Line integral of a complex function-Cauchy's theorem and Cauchy's integral formula and problems.

Module-3

Probability Distributions: Review of basic probability theory. Random variables (discrete and continuous), probability mass/density functions. Binomial, Poisson, exponential and normal distributions- problems (No derivation for mean and standard deviation)-Illustrative examples.

Module-4

Statistical Methods: Correlation and regression-Karl Pearson's coefficient of correlation and rank correlation -problems. Regression analysis- lines of regression –problems.
Curve Fitting: Curve fitting by the method of least squares- fitting the curves of the form-
$y = ax + b, y = ax^b and y = ax^2 + bx + c.$

Module-5

Joint probability distribution: Joint Probability distribution for two discrete random variables, expectation and covariance.
Sampling Theory: Introduction to sampling distributions, standard error, Type-I and Type-II errors. Test of hypothesis for means, student's t-distribution, Chi-square distribution as a test of goodness of fit.

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

- Use the concepts of analytic function and complex potentials to solve the problems arising in electromagnetic field theory.
- Utilize conformal transformation and complex integral arising in aerofoil theory, fluid flow visualization and image processing.
- Apply discrete and continuous probability distributions in analyzing the probability models arising in engineering field.
- Make use of the correlation and regression analysis to fit a suitable mathematical model for the statistical data.
- Construct joint probability distributions and demonstrate the validity of testing the hypothesis.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Edition,2016
2	Higher Engineering Mathematics	B. S. Grewal	Khanna Publishers	44th Edition, 2017
3	Engineering Mathematics	Srimanta Pal et al	Oxford University Press	3rd Edition,2016
Reference Books				
1	Advanced Engineering Mathematics	C. Ray Wylie, Louis C.Barrett	McGraw-Hill	6th Edition 1995
2	Introductory Methods of Numerical Analysis	S.S.Sastry	Prentice Hall of India	4th Edition 2010
3	Higher Engineering Mathematics	B. V. Ramana	McGraw-Hill	11th Edition,2010
4	A Text Book of Engineering Mathematics	N. P. Bali and Manish Goyal	Laxmi Publications	2014

Web links and Video Lectures:

1. http://nptel.ac.in/courses.php?disciplineID=111
2. http://www.class-central.com/subject/math(MOOCs)
3. http://academicearth.org/
4. VTU EDUSAT PROGRAMME - 20

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

APPLIED THERMODYNAMICS

Course Code	**18ME42**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:2:0	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To understand the applications of the first and second laws of Thermodynamics to various gas processes and cycles.
- To understand fundamentals of I. C. Engines, Construction and working Principle of an Engine and Compare Actual, Fuel-Air and Air standard cycle Performance.
- To study Combustion in SI and CI engines and its controlling factor in order to extract maximum power.
- To know the concepts of testing of I. C. Engines and methods to estimate Indicated, Brake and Frictional Power and efficiencies.
- To understand theory and performance Calculation of Positive displacement compressor.
- To understand the concepts related to Refrigeration and Air conditioning.
- To get conversant with Psychrometric Charts, Psychrometric processes, human comfort conditions.

Module-1

Air standard cycles: Carnot, Otto, Diesel, Dual and Stirling cycles, p-v and T -s diagrams, description, efficiencies and mean effective pressures. Comparison of Otto and Diesel cycles.
I.C.Engines: Classification of IC engines, Combustion of SI engine and CI engine, Detonation and factors affecting detonation, Performance analysis of I.C Engines, Heat balance, Morse test, IC Engine fuels, Ratings and Alternate Fuels.

Module-2

Gas power Cycles: Gas turbine (Brayton) cycle; description and analysis. Regenerative gas turbine cycle. Inter-cooling and reheating in gas turbine cycles. Introduction to Jet Propulsion cycles.

Module-3

Vapour Power Cycles: Carnot vapour power cycle, drawbacks as a reference cycle. Simple Rankine cycle; description, T-S diagram, analysis for performance. Comparison of Carnot and Rankine cycles. Effects of pressure and temperature on Rankine cycle performance.
Actual vapour power cycles. Ideal and practical regenerative Rankine cycles, open and closed feed water heaters. Reheat Rankine cycle. Characteristics of an Ideal working fluid in vapour power cycles.

Module-4

Refrigeration Cycles: Vapour compression refrigeration system; description, analysis, refrigerating effect. Capacity, power required units of refrigeration, COP, Refrigerants and their desirable properties, alternate Refrigerants. Air cycle refrigeration; reversed Carnot cycle, reversed Brayton cycle, vapour absorption refrigeration system.
Pscychrometrics and Air-conditioning Systems: Psychometric properties of Air, Psychometric Chart, Analyzing Air-conditioning Processes; Heating, Cooling, Dehumidification and Humidification, Evaporative Cooling. Adiabatic mixing of two moist air streams. Cooling towers.

Module-5

Reciprocating Compressors: Operation of a single stage reciprocating compressors. Work input through p-v diagram and steady state steady flow analysis. Effect of Clearance and Volumetric efficiency. Adiabatic, Isothermal and Mechanical efficiencies. Multi-stage compressor, saving in work, Optimum intermediate pressure, Inter-cooling, Minimum work for compression.
Steam nozzles: Flow of steam through nozzles, Shape of nozzles, effect of friction, Critical pressure ratio, Supersaturated flow.

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

CO1: Apply thermodynamic concepts to analyze the performance of gas power cycles.
CO2: Apply thermodynamic concepts to analyze the performance of vapour power cycles.
CO3: Understand combustion of fuels and performance of I C engines.
CO4: Understand the principles and applications of refrigeration systems.
CO5: Apply Thermodynamic concepts to determine performance parameters of refrigeration and air-conditioning systems.
CO6: Understand the working principle of Air compressors and Steam nozzles, applications, relevance of air and identify methods for performance improvement.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Engineering Thermodynamics	P.K. Nag	Tata McGraw Hill	6th Edition 2018
2	Applications of Thermodynamics	V.Kadambi, T. R.Seetharam, K. B. Subramanya Kumar	Wiley Indian Private Ltd	1st Edition 2019
3	Thermodynamics	Yunus A, Cengel, Michael A Boles	Tata McGraw Hill	7th Edition
Reference Books				
1	Thermodynamics for engineers	Kenneth A. Kroos and Merle C. Potter	Cengage Learning	2016
2	Principles of Engineering Thermodynamics	Michael J, Moran, Howard N. Shapiro	Wiley	8th Edition
3	An Introduction to Thermo Dynamics	Y.V.C.Rao	Wiley Eastern Ltd	2003.
4	Thermodynamics	Radhakrishnan	PHI	2nd revised edition
5	I.C Engines	Ganeshan.V	Tata McGraw Hill	4th Edi. 2012
6	I.C.Engines	M.L.Mathur& Sharma.	Dhanpat Rai& sons-India	

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – IV

FLUID MECHANICS

Course Code	**18ME43**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To have a working knowledge of the basic properties of fluids and understand the continuum approximation.
- To calculate the forces exerted by a fluid at rest on submerged surfaces and understand the force of buoyancy.
- To understand the flow characteristic and dynamics of flow field for various engineering applications.
- To know how velocity changes and energy transfers in fluid flows are related to forces and torques and to understand why designing for minimum loss of energy in fluid flows is so important.
- To discuss laminar and turbulent flow and appreciate their differences and the concept of boundary layer theory.
- To understand the concept of dynamic similarity and how to apply it to experimental modelling.
- To appreciate the consequences of compressibility in gas flow and understand the effects of friction and heat transfer on compressible flows.

Module-1

Basics: Introduction, Properties of fluids-mass density, weight density, specific volume, specific gravity, viscosity, surface tension, capillarity, vapour pressure, compressibility and bulk modulus. Concept of continuum, types of fluids etc., pressure at a point in the static mass of fluid, variation of pressure. Pascal's law, absolute, gauge, atmospheric and vacuum pressures; pressure measurement by simple, differential manometers and mechanical gauges.

Fluid Statics: Total pressure and centre of pressure for horizontal plane, vertical plane surface and inclined plane surface submerged in static fluid.

Module-2

Buoyancy, center of buoyancy, meta center and meta centric height its application.

Fluid Kinematics: Velocity of fluid particle, types of fluid flow, description of flow, continuity equation, Coordinate free form, acceleration of fluid particle, rotational & irrotational flow, Laplace's equation in velocity potential and Poisson's equation in stream function, flow net.

Module-3

Fluid Dynamics; Introduction. Forces acting on fluid in motion. Euler's equation of motion along a streamline. Integration of Euler's equation to obtain Bernoulli's equation, Assumptions and limitations of Bernoulli's equation. Introduction to Navier-Stokes equation. Application of Bernoulli's theorem such as venturi-meter, orifice meter, rectangular and triangular notch, pitot tube.

Laminar and turbulent flow: Flow through circular pipe, between parallel plates, Power absorbed in viscous flow in bearings, Poiseuille equation – velocity profile loss of head due to friction in viscous flow. Reynolds's experiment, frictional loss in pipe flow. Introduction to turbulence, characteristics of turbulent flow, laminar-turbulent transition major and minor losses.

Module-4

Flow over bodies: Development of boundary layer, Prandtl‟s boundary layer equations, Blasius solution, integral momentum equation, drag on a flat plate, boundary layer separation and its control, streamlined and bluff bodies -flow around circular bodies and aero foils, calculation of lift and drag.

Dimensional analysis: Introduction, derived quantities, dimensions of physical quantities, dimensional homogeneity, Rayleigh's method, Buckingham Pi-theorem, dimensionless numbers, similitude, types of similitude.

Module-5

Compressible Flows: Introduction, thermodynamic relations of perfect gases, internal energy and enthalpy, speed of sound, pressure field due to a moving source, basic Equations for one-dimensional flow, stagnation and sonic properties, normal and oblique shocks.
Introduction to CFD: Necessity, limitations, philosophy behind CFD, applications.

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

CO1: Identify and calculate the key fluid properties used in the analysis of fluid behavior.

CO2: Explain the principles of pressure, buoyancy and floatation

CO3: Apply the knowledge of fluid statics, kinematics and dynamics while addressing problems of mechanical and chemical engineering.

CO4: Describe the principles of fluid kinematics and dynamics.

CO5: Explain the concept of boundary layer in fluid flow and apply dimensional analysis to form dimensionless numbers in terms of input output variables.

CO6: Illustrate and explain the basic concept of compressible flow and CFD

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	A Text Book of Fluid Mechanis And Hydraulic Machines	Dr R.K Bansal	Laxmi Publishers	
2	Fluid Mechanics	F M White	McGraw Hill Publications	Eighth edition. 2016
3	Fluid Mechanics (SI Units)	Yunus A. Cengel John M.Cimbala	TataMcGraw Hill	3rd Ed.,2014.
Reference Books				
1	Fluid Mechanics	F M White	McGraw Hill Publications	Eighth edition. 2016
2	Fundamentals of Fluid Mechanics	Munson, Young, Okiishi&Huebsch,	John Wiley Publications	7th edition
3	Fluid Mechanics	Pijush.K.Kundu, IRAM COCHEN	ELSEVIER	3rd Ed. 2005
4	Fluid Mechanics	John F.Douglas, Janul and M.Gasiosek and john A.Swaffield	Pearson Education Asia	5th ed., 2006
5	Introduction to Fluid Mechanics	Fox, McDonald	John Wiley Publications	8th edition.

E- Learning

- Nptel.ac.in
- VTU, E- learning
- MOOCS
- Open courseware

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – IV

KINEMATICS OF MACHINES

Course Code	**18ME44**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the concept of machines, mechanisms and related terminologies.
- To expose the students to various mechanisms and motion transmission elements used in Mechanical Engineering.
- To analyze a mechanism for displacement, velocity and acceleration at any point in a moving link.
- To understand the theory of cams, gears and gear trains.

Module-1

Mechanisms: Definitions: Link , types of links, joint, types of joints kinematic pairs, Constrained motion, kinematic chain, mechanism and types , degrees of freedom of planar mechanisms, Equivalent mechanisms, Groshoff's criteria and types of four bar mechanisms, , inversions of of four bar chain, slider crank chain, Doubler slider crank chain and its inversions, Grashoff's chain. Mechanisms: Quick return motion mechanisms-Drag link mechanism, Whitworth mechanism and Crank and slotted lever Mechanism. Straight line motion mechanisms, Peaucellier's mechanism and Robert's mechanism. Intermittent Motion mechanisms: Geneva wheel mechanism, Ratchet and Pawl mechanism, toggle mechanism, pantograph, condition for correct steering, Ackerman steering gear mechanism.

Module-2

Velocity and Acceleration Analysis of Mechanisms (Graphical Method): Velocity and acceleration analysis of four bar mechanism, slider crank mechanism. Mechanism illustrating Corioli's component of acceleration. Angular velocity and angular acceleration of links, velocity of rubbing. Velocity Analysis by Instantaneous Center Method: Definition, Kennedy's theorem, Determination of linear and angular velocity using instantaneous center method.

Module-3

Velocity and Acceleration Analysis of Mechanisms (Analytical Method): Velocity and acceleration analysis of four bar mechanism, slider crank mechanism using complex algebra method. Freudenstein's equation for four bar mechanism and slider crank mechanism. Function Generation for four bar mechanism.

Module-4

Cams: Classification of cams, Types of followers, Cam nomenclature, Follower motions and motion analysis, of SHM, Motion with uniform acceleration and deceleration, uniform velocity, cycloidal motion, Cam profile with offset knife edge follower, roller follower, flat faced follower.

Module-5

Spur Gears: Gear terminology, law of gearing, path of contact, arc of contact, contact ratio of spur gear. Interference in involute gears, methods of avoiding interference, condition and expressions for minimum number of teeth to avoid interference.

Gear Trains: Simple gear trains, compound gear trains. Epicyclic gear trains: Algebraic and tabular methods of finding velocity ratio of epicyclic gear trains, torque calculation in epicyclic gear trains.

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

CO1: Knowledge of mechanisms and their motion.

CO2: Understand the inversions of four bar mechanisms.

CO3: Analyse the velocity, acceleration of links and joints of mechanisms.

CO4: Analysis of cam follower motion for the motion specifications.

CO5: Understand the working of the spur gears.
CO6: Analyse the gear trains speed ratio and torque.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Theory of Machines Kinematics and Dynamics	Sadhu Singh	Pearson	Third edition 2019
2	Mechanism and Machine Theory	G. Ambekar	PHI	2009
Reference Books				
1	Theory of Machines	Rattan S.S	Tata McGraw-Hill Publishing Company	2014
2	Mechanisms and Machines-Kinematics, Dynamics and Synthesis	Michael M Stanisic	Cengage Learning	2016

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – IV

METAL CUTTING AND FORMING

Course Code	**18ME35A/45A**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To enrich the knowledge pertaining to relative motion and mechanics required for various machine tools.
- To introduce students to different machine tools to produce components having different shapes and sizes.
- To develop the knowledge on mechanics of machining process and effect of various parameters on machining.
- To acquaint with the basic knowledge on fundamentals of metal forming processes
- To study various metal forming processes.

Module-1

Introduction to Metal cutting: Orthogonal and oblique cutting. Classification of cutting tools: single, and multipoint; tool signature for single point cutting tool. Mechanics of orthogonal cutting; chip formation, shear angle and its significance, Merchant circle diagram. Numerical problems.
Cutting tool materials and applications.
Introduction to basic metal cutting machine tools: Lathe- Parts of lathe machine, accessories of lathe machine, and various operations carried out on lathe. Kinematics of lathe. Turret and Capstan lathe.

Module-2

Milling: Various Milling operation, classification of milling machines, Vertical & Horizontal milling, up milling & down milling. Indexing: need of indexing, simple, compound & differential indexing.
Drilling: Difference between drilling, boring & reaming, types of drilling machines. Boring operations & boring machines.
Shaping, Planing and Slotting machines-machining operations and operating parameters.
Grinding: Grinding operation, classification of grinding processes: cylindrical, surface & centerless grinding

Module-3

Introduction to tool wear, tool wear mechanisms, tool life equations, effect of process parameters on tool life, machinability. Cutting fluid-types and applications, surface finish, effect of machining parameters on surface finish. Economics of machining process, choice of cutting speed and feed, tool life for minimum cost and production time. Numerical problems.

Module-4

MECHANICAL WORKING OF METALS Introduction to metal forming processes & classification of metal forming processes. Hot working & cold working of metals.
Forging: Smith forging, drop forging & press forging. Forging Equipment, Defects in forging.
Rolling: Rolling process, Angle of bite, Types of rolling mills, Variables of rolling process, Rolling defects.
Drawing & Extrusion: Drawing of wires, rods & pipes, Variables of drawing process. Difference between drawing & extrusion. Various types of extrusion processes.

Module-5

Sheet Metal Operations: Blanking, piercing, punching, drawing, draw ratio, drawing force, variables in drawing, Trimming, and Shearing.
Bending — types of bending dies, Bending force calculation, Embossing and coining.
Types of dies: Progressive, compound and combination dies.

Course Outcomes:

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

CO1: Explain the construction & specification of various machine tools.
CO2: Discuss different cutting tool materials, tool nomenclature & surface finish.
CO3: Apply mechanics of machining process to evaluate machining time.

CO4: Analyze tool wear mechanisms and equations to enhance tool life and minimize machining cost.
CO5: Understand the concepts of different metal forming processes.
CO6: Apply the concepts of design of sheet metal dies to design different dies for simple sheet metal components.

Question paper pattern:

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

Sl. N	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Manufacturing Technology Vol I & II	P.N.Rao	Tata McGraw Hill Pub. Co. Ltd., New Delhi	1998
2	A textbook of Production Technology Vol I and II	Sharma, P.C.,	S. Chand & Company Ltd., New Delhi	1996
3	Manufacturing Science	Amithab Gosh &A.K.Malik	East-West press	2001
Reference Books				
3	Workshop Technology Vol. I and II	Chapman W. A. J.	Arnold Publisher New Delhi	1998
4	Elements of Manufacturing Technology Vol II,	Hajra Choudhary, S. K. and Hajra Choudhary, A. K.	Media Publishers, Bombay	1988
5	Metal Forming Handbook	Schuler	Springer Verlag Publication	
6	Metal Forming: Mechanics and Metallurgy	Hosford,WF and Caddell,R.M	Prentice Hall	1993
7	Manufacturing Engineering and Technology	Kalpakjian	Addision Wesley Congmen Pvt. Ltd.	2000
8	Production Technology	HMT		

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – IV

METAL CASTING AND WELDING

Course Code	**18ME35B/45B**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To provide adequate knowledge of quality test methods conducted on welded and cast components.
- To provide knowledge of various casting process in manufacturing.
- To provide in-depth knowledge on metallurgical aspects during solidification of metal and alloys.
- To provide detailed information about the moulding processes.
- To impart knowledge of various joining process used in manufacturing.
- To impart knowledge about behaviour of materials during welding, and the effect of process parameters in welding,

Module-1

Introduction & basic materials used in foundry:
Introduction: Definition, Classification of manufacturing processes. Metals cast in the foundry-classification, factors that determine the selection of a casting alloy.
Introduction to casting process & steps involved:
Patterns: Definition, classification, materials used for pattern, various pattern allowances and their importance.
Sand moulding: Types of base sand, requirement of base sand. Binder, Additives definition, need and types; preparation of sand moulds. Melding machines- Jolt type, squeeze type and Sand slinger.
Study of important moulding process: Green sand, core sand, dry sand, sweep mould, CO_2mould, shell mould, investment mould, plaster mould, cement bonded mould.
Cores: Definition, need, types. Method of making cores,
Concept of gating (top, bottom, parting line, horn gate) and risers (open, blind) Functions and types.

Module-2

MELTING & METAL MOLD CASTING METHODS:
Melting furnaces: Classification of furnaces, Gas fired pit furnace, Resistance furnace, Coreless induction furnace, electric arc furnace, constructional features & working principle of cupola furnace.
Casting using metal moulds: Gravity die casting, pressure die casting, centrifugal casting, squeeze casting, slush casting, thixocasting, and continuous casting processes.

Module-3

SOLIDIFICATION & NON-FERROUS FOUNDRY PRACTICE: Solidification: Definition, nucleation, solidification variables. Directional solidification-need and methods. Degasification in liquid metals-sources of gas, degasification methods.
Fettling and cleaning of castings: Basic steps involved. Sand Casting defects- causes, features and remedies. Advantages & limitations of casting process
Nonferrous foundry practice: Aluminium castings - advantages, limitations, melting of Aluminium using lift-out type crucible furnace. Hardeners used, drossing, gas absorption, fluxing and flushing, grain refining, pouring temperature. Stir casting set up, procedure, uses, advantages and limitations

Module-4

Welding process: Definition, Principles, classification, application, advantages & limitations of welding. Arc welding: Principle, Metal arc welding (MAW), Flux Shielded Metal Arc Welding (FSMAW), Inert Gas Welding (TIG & MIG) Submerged Arc Welding (SAW) and Atomic Hydrogen Welding (AHW).
Special type of welding: Resistance welding principles, Seam welding, Butt welding, Spot welding and Projection welding. Friction welding, Explosive welding, Thermit welding, Laser welding and Electron beam welding.

Module-5

METALLURGICAL ASPECTS IN WELDING, SOLDERING, AND BRAZING

Structure of welds, Formation of different zones during welding, Heat Affected Zone (HAZ), Parameters affecting HAZ. Effect of carbon content on structure and properties of steel, Shrinkage in welds& Residual stresses. Concept of electrodes, filler rod and fluxes. Welding defects- detection causes & remedy.

Soldering, brazing, gas welding: Soldering, Brazing, Gas Welding: Principle, oxy-Acetylene welding, oxy-hydrogen welding, air-acetylene welding, Gas cutting, powder cutting.

Inspection methods: Methods used for inspection of casting and welding. Visual, magnetic particle, fluorescent particle, ultrasonic. Radiography, eddy current, holography methods of inspection.

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

CO1: Describe the casting process and prepare different types of cast products.

CO2: Acquire knowledge on Pattern, Core, Gating, Riser system and to use Jolt, Squeeze, Sand Slinger moulding machines.

CO3: Compare the Gas fired pit, Resistance, Coreless, Electrical and Cupola Metal Furnaces.

CO4: Compare the Gravity, Pressure die, Centrifugal, Squeeze, slush and Continuous Metal mould castings.

CO5: Understand the Solidification process and Casting of Non-Ferrous Metals.

CO6: Describe the Metal Arc, TIG, MIG, Submerged and Atomic Hydrogen Welding processes etc. used in manufacturing.

CO7: Describe methods for the quality assurance of components made of casting and joining process

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Principles of metal casting	Rechard W. Heine, Carl R. Loper Jr., Philip C. Rosenthal	Tata McGraw Hill Education Private Limited	1976
2	Manufacturing Process-I	Dr. K. Radhakrishna	Sapna Book House,	5th Revised Edition 2009.
3	Manufacturing Technology- Foundry, Forming and Welding	P.N.Rao	Tata McGraw Hill	3rd Ed., 2003.
Reference Books				
4	Process and Materials of Manufacturing	Roy A Lindberg	Pearson Edu	4th Ed. 2006
5	Manufacturing Technology	SeropeKalpakjianS teuen. R Sechmid	Pearson Education Asia	5th Ed. 2006

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

COMPUTER AIDED MACHINE DRAWING

Course Code	**18ME36A/46A**	CIE Marks	40
Teaching Hours/Week (L:T:P)	1:4:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To acquire the knowledge of CAD software and its features.
- To familiarize the students with Indian Standards on drawing practices.
- To impart knowledge of thread forms, fasteners, keys, joints and couplings.
- To make the students understand and interpret drawings of machine components leading to preparation of assembly drawings manually and using CAD packages.
- To acquire the knowledge of limits, tolerance and fits and indicate them on machine drawings.

Part A

Part A

Introduction:
Review of graphic interface of the software. Review of basic sketching commands and navigational commands. Starting a new drawing sheet. Sheet sizes. Naming a drawing, Drawing units, grid and snap. Conversion of pictorial views into orthographic projections of simple machine parts (with and without section). Hidden line conventions. Precedence of lines.
Sections of Solids: Sections of Pyramids, Prisms, Cubes, Tetrahedrons, Cones and Cylinders resting only on their bases (No problems on axis inclinations, spheres and hollow solids). True shape of sections.
Conversion of pictorial views into orthographic projections of simple machine parts. Hidden line conventions. Precedence of lines.
Conversion of pictorial views into orthographic projections of simple machine parts (with section planes indicated on the part).
Thread Forms: Thread terminology, sectional views of threads. ISO Metric (Internal & External), BSW (Internal & External) square and Acme. Sellers thread, American Standard thread.
Fasteners: Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly) simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, counter sunk head screw, grub screw, Allen screw.

Part B

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

Part C

Limits, Fits and Tolerances: Introduction, Fundamental tolerances, Deviations, Methods of placing limit dimensions, machining symbols, types of fits with symbols and applications, geometrical tolerances on drawings. Standards followed in industry.
Assembly Drawings: (Part drawings shall be given)
1. Plummer block (Pedestal Bearing)
2. Lever Safety Valve
3. I.C. Engine connecting rod
4. Screw jack (Bottle type)
5. Tailstock of lathe
6. Machine vice
7. Tool head of shaper

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

CO1: Identify the national and international standards pertaining to machine drawing.
CO2: Understand the importance of the linking functional and visualization aspects in the preparation of the part drawings
CO3: Apply limits and tolerances to assemblies and choose appropriate fits for given assemblies.
CO4: Interpret the Machining and surface finish symbols on the component drawings.
CO5: Preparation of the part or assembly drawings as per the conventions.

Scheme of Examination: Two questions to be set from each Part A, part B and Part C. Student has to answer one question each from Part A and Part B for 25 marks each and one question from Part C for 50 marks.

INSTRUCTION FOR COMPUTER AIDED MACHINE DRAWING (15ME36A/46A) EXAMINATION

1. No restriction of timing for sketching/ computerization of solutions. The total duration is 3 hours.
2. It is desirable to do sketching of all the solutions before computerization.
3. Drawing instruments may be used for sketching.
4. For Part A and Part B, 2D drafting environment should be used.
5. For Part C, 3D environment should be used for parts and assembly, and extract 2D views of assembly.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Machine Drawing	K.R. Gopala Krishna	Subhash Publication	2005
2	Machine Drawing	N.D.Bhat&V.M.Panchal	Charoratar publishing house	2005
Reference Books				
3	A Text Book of Computer Aided Machine Drawing	S. Trymbaka Murthy	CBS Publishers, New Delhi	2007
4	Engineering drawing	P.S.Gill	S K Kataria and Sons	2013
5	Machine Drawing	N. Siddeshwar, P. Kanniah, V.V.S. Sastri	Tata McGraw Hill	2006

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

MECHANICAL MEASUREMENTS AND METROLOGY

Course Code	**18ME36B/46B**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the concept of metrology and standards of measurement.
- To equip with knowledge of limits, fits, tolerances and gauging
- To acquire knowledge of linear and Angular measurements, Screw thread and gear measurement & comparators.
- To understand the knowledge of measurement systems and methods with emphasis on different Transducers, intermediate modifying and terminating devices.
- To understand the measurement of Force, Torque, Pressure, Temperature and Strain.

Module-1

Introduction to Metrology: Definition, objectives of metrology, Material Standards, Wavelength Standards, Classification of standards, Line and End standards, Calibration of End bars. Numerical examples.

Liner measurement and angular measurements: Slip gauges-Indian standards on slip gauges, Adjustable slip gauges, Wringing of slip gauges, Problems on building of slip gauges (M87, M112), Measurement of angle-sine bar, Sine centre, Angle gauges, Optical instruments for angular measurements. Autocollimator-Applications for measuring straightness and squareness.

Module-2

System of Limits, Fits, Tolerance and Gauging: Definitions, Tolerance, Tolerance analysis (addition & subtraction of tolerances) Inter change ability & Selective assembly. Class &grade of tolerance, Fits, Types of fits, Numerical on limits, fit and tolerance. Hole base system & shaft base system. Taylor's principle, Types of limit gauges, Numerical on limit gauge design.

Comparators: Functional requirements, Classification, Mechanical- Johnson Mikrokator, Sigma comparators, Dial indicator, Electrical comparators, LVDT, Pneumatic comparators- Principle of back pressure, Solex comparators, Optical comparators- Zeiss ultra- optimeter.

Module-3

Measurement of screw thread and gear: Terminology of screw threads, Measurement of major diameter, Minor diameter, Pitch, Angle and Effective diameter of screw threads by 2- wire and 3-wire methods, Best size wire. Screw thread gauges, Toolmaker's microscope.

Gear tooth Measurements: Tooth thickness measurement using constant chord method, Addendum, Comparator method and Base tangent method, Measurement of pitch, Concentricity, Run out and In volute profile. Gear roll tester for composite error.

Module-4

Measurement system and basic concepts of measurement methods: Definition, Significance of measurement, generalized measurement system, Static characteristics- Accuracy, Precision, Calibration, Threshold, Sensitivity, Hysteresis, Repeatability, Linearity, Loading effect, Dynamic characteristics- System response, Time delay. Errors in measurement, Classification of errors.

Transducers: Transfer efficiency, Primary and Secondary transducers, Electrical transducers, Mechanical transducers, Electronic transducers, Relative comparison of each type of transducers.

Intermediate Modifying and Terminating Devices: Mechanical systems, Inherent problems, Electrical intermediate modifying devices, Input circuitry, Ballast circuit, Electronic amplifiers. Terminating devices, Cathode ray oscilloscope,Oscillographs.

Module-5

Applied mechanical measurement: Measurement of force, Torque, Pressure, Types of Dynamometers, Absorption dynamometer, Prony brake and Rope brake dynamometer, and Power Measuring Instruments. Use of elastic members, Bridgeman gauge, McLeod gauge, Pirani gauge.

Measurement of strain and temperature: Theory of strain gauges, Types, Electrical resistance strain gauge, Preparation and mounting of Strain gauges, Gauge factor, Methods of strain measurement, temperature compensation, Resistance thermometers, Thermocouple, Law of thermocouple, Pyrometer, Optical pyrometer.

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

CO1: Understand the objectives of metrology, methods of measurement, standards of measurement & various measurement parameters.

CO2: Explain tolerance, limits of size, fits, geometric and position tolerances, gauges and their design

CO3: Understand the working principle of different types of comparators.

CO3: Describe measurement of major & minor diameter, pitch, angle and effective diameter of screw threads.

CO4: Explain measurement systems, transducers, intermediate modifying devices and terminating devices..

CO5: Describe functioning of force, torque, pressure, strain and temperature measuring devices.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Mechanical Measurements	Beckwith Marangoni and Lienhard	Pearson Education	6th Ed., 2006
2	Instrumentation, Measurement and Analysis	B C Nakra, K K Chaudhry	McGraw–Hill	4th Edition
3	Engineering Metrology	R.K. Jain	Khanna Publishers	2009
Reference Books				
1	Engineering Metrology and Measurements	Bentley	PearsonEducation	
2	Theory and Design for Mechanical Measurements, III edition	Richard S Figliola, Donald E Beasley	WILEY IndiaPublishers	
3	Engineering Metrology	Gupta I.C	Dhanpat RaiPublications	
4	Deoblin's Measurement system,	Ernest Deoblin, Dhanesh manick	McGraw–Hill	
5	EngineeringMetrologyandMeasurements	N.V.RaghavendraandL.Krishnamurthy	Oxford UniversityPress.	

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

MATERIAL TESTING LAB

Course Code	**18MEL37A/47A**	CIE Marks	40
Teaching Hours /Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To learn the concept of the preparation of samples to perform characterization such as microstructure, volume fraction of phases and grain size.
- To understand mechanical behaviour of various engineering materials by conducting standard tests.
- To learn material failure modes and the different loads causing failure.
- To learn the concepts of improving the mechanical properties of materials by different methods like heat treatment, surface treatment etc.

Sl. No.	Experiments
	PART A
1	Preparation of specimen for Metallographic examination of different engineering materials. To report microstructures of plain carbon steel, tool steel, gray C.I, SG iron, Brass, Bronze & composites.
2	Heat treatment: Annealing, normalizing, hardening and tempering of steel. Metallographic specimens of heat treated components to be supplied and students should report microstructures of furnace cooled, water cooled, air cooled, tempered steel. Students should be able to distinguish the phase changes in a heat treated specimen compared to untreated specimen.
3	Brinell, Rockwell and Vickers's Hardness tests on untreated and heat treated specimens.
4	To study the defects of Cast and Welded components using Non-destructive tests like: d) Ultrasonic flaw detection e) Magnetic crack detection f) Dye penetration testing.
	PART B
5	Tensile, shear and compression tests of steel, aluminum and cast iron specimens using Universal Testing Machine
6	Torsion Test on steel bar.
7	Bending Test on steel and wood specimens.
8	Izod and Charpy Tests on Mild steel and C.I Specimen.
9	To study the wear characteristics of ferrous and non-ferrous materials under different parameters.
10	Tensile, shear and compression tests of steel, aluminum and cast iron specimens using Universal Testing Machine
11	Fatigue Test (demonstration only).

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

CO1: Acquire experimentation skills in the field of material testing.

CO2: Develop theoretical understanding of the mechanical properties of materials by performing experiments.

CO3: Apply the knowledge to analyse a material failure and determine the failure inducing agent/s.

CO4: Apply the knowledge of testing methods in related areas.

CO5: Understand how to improve structure/behaviour of materials for various industrial applications.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Scheme of Examination:

ONE question from part -A:	30 Marks
ONE question from part -B:	50 Marks
Viva -Voice:	20 Marks
Total:	100 Marks

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

MECHANICAL MEASUREMENTS AND METROLOGY LAB

Course Code	**18MEL37B/47B**	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To illustrate the theoretical concepts taught in Mechanical Measurements & Metrology through experiments.
- To illustrate the use of various measuring tools & measuring techniques.
- To understand calibration techniques of various measuring devices.

Sl. No.	Experiments
	PART A
1	Calibration of Pressure Gauge
2	Calibration of Thermocouple
3	Calibration of LVDT
4	Calibration of Load cell
5	Determination of modulus of elasticity of a mild steel specimen using strain gauges.
	PART B
6	Measurements using Optical Projector / Toolmakers' Microscope.
7	Measurement of angle using Sine Centre / Sine bar / bevel protractor
8	Measurement of alignment using Autocollimator / Roller set
9	Measurement of cutting tool forces using: Lathe tool Dynamometer Drill tool Dynamometer.
10	Measurements of Screw thread parameters using two wire or three-wire methods.
11	Measurements of surface roughness using Tally Surf/Mechanical Comparator
12	Measurement of gear tooth profile using gear tooth Vernier/Gear tooth micrometer
13	Calibration of Micrometer using slip gauges
14	Measurement using Optical Flats

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

CO1: Understand Calibration of pressure gauge, thermocouple, LVDT, load cell, micrometer.
CO2: Apply concepts of Measurement of angle using Sine Centre/ Sine Bar/ Bevel Protractor, alignment using Autocollimator/ Roller set.
CO3: Demonstrate measurements using Optical Projector/Tool maker microscope, Optical flats.
CO4: Analyse tool forces using Lathe/Drill tool dynamometer.
CO5: Analyse Screw thread parameters using 2-Wire or 3-Wire method, gear tooth profile using gear tooth Vernier/Gear tooth micrometer
CO6: Understand the concepts of measurement of surface roughness.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.

Scheme of Examination:

ONE question from part -A: 30 Marks
ONE question from part -B: 50 Marks
Viva -Voice: 20 Marks
Total: 100 Marks

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

WORKSHOP AND MACHINE SHOP PRACTICE

Course Code	**18MEL38A/48A**	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To guide students to use fitting tools to perform fitting operations.
- To provide an insight to different machine tools, accessories and attachments.
- To train students into fitting and machining operations to enrich their practical skills.
- To inculcate team qualities and expose students to shop floor activities.
- To educate students about ethical, environmental and safety standards.

Sl. No.	Experiments
	PART A
1	Preparation of at least two fitting joint models by proficient handling and application of hand tools- V-block, marking gauge, files, hack saw drills etc.
	PART B
2	Preparation of three models on lathe involving - Plain turning, Taper turning, Step turning, Thread cutting, Facing, Knurling, Drilling, Boring, Internal Thread cutting and Eccentric turning. Exercises should include selection of cutting parameters and cutting time estimation.
	PART C
3	Cutting of V Groove/ dovetail / Rectangular groove using a shaper. Cutting of Gear Teeth using Milling Machine. Exercises should include selection of cutting parameters and cutting time estimation.
	PART D (DEMONSTRATION ONLY)
	Study & Demonstration of power tools like power drill, power hacksaw, portable hand grinding, cordless screw drivers, production air tools, wood cutter, etc., used in Mechanical Engineering.

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

CO1: To read working drawings, understand operational symbols and execute machining operations.
CO2: Prepare fitting models according to drawings using hand tools- V-block, marking gauge, files, hack saw, drills etc.
CO3: Understand integral parts of lathe, shaping and milling machines and various accessories and attachments used.
CO4: Select cutting parameters like cutting speed, feed, depth of cut, and tooling for various machining operations.
CO5: Perform cylindrical turning operations such as plain turning, taper turning, step turning, thread Cutting, facing, knurling, internal thread cutting, eccentric turning and estimate cutting time.
CO6: Perform machining operations such as plain shaping, inclined shaping, keyway cutting, Indexing and Gear cutting and estimate cutting time.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Updated on 16.04.2020/28092020

Scheme of Examination:	
One Model from Part-A or Part-C:	30 Marks
One Model from Part-B:	50 Marks
Viva – Voce:	20 Marks
TOTAL:	100 Marks

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

FOUNDRY, FORGING AND WELDING LAB

Course Code	**18MEL38B/48B**	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To provide an insight into different sand preparation and foundry equipment.
- To provide an insight into different forging tools and equipment and arc welding tools and equipment.
- To provide training to students to enhance their practical skills in welding, forging and hand moulding.

Sl. No.	Experiments
	PART A
1	**Testing of Molding sand and Core sand.** **Preparation of sand specimens and conduction of the following tests:** 1. Compression, Shear and Tensile tests on Universal Sand Testing Machine. 2. Permeability test 3. Sieve Analysis to find Grain Fineness Number (GFN) of Base Sand 4. Clay content determination on Base Sand. **Welding Practice:** Use of Arc welding tools and welding equipment Preparation of welded joints using Arc Welding equipment L-Joint, T-Joint, Butt joint, V-Joint, Lap joints on M.S. flats
	PART B
2	**Foundry Practice:** **Use of foundry tools and other equipment for Preparation of molding sand mixture.** **Preparation of green sand molds kept ready for pouring in the following cases:** 4. Using two molding boxes (hand cut molds). 5. Using patterns (Single piece pattern and Split pattern). 6. Incorporating core in the mold.(Core boxes). • Preparation of one casting (Aluminium or cast iron-Demonstration only)
	PART C
3	**Forging Operations:** Use of forging tools and other forging equipment. • Calculation of length of the raw material required to prepare the model considering scale loss. • Preparing minimum three forged models involving upsetting, drawing and bending operations.

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

- Demonstrate various skills in preparation of molding sand for conducting tensile, shear and compression tests using Universal sand testing machine.
- Demonstrate skills in determining permeability, clay content and Grain Fineness Number of base sands.
- Demonstrate skills in preparation of forging models involving upsetting, drawing and bending operations.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Scheme of Examination:

1. One question is to be set from Part-A: 30 marks. (20 marks for sand testing+ 10 Marks for welding)
2. One question is to be set from either Part-B or Part-C: 50 Marks
3. Viva – Voce: 20 marks

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

CO1: Understand needs, functions, roles, scope and evolution of Management.

CO2: Understand importance, purpose of Planning and hierarchy of planning and also53nalyse its types.

CO3: Discuss Decision making, Organizing, Staffing, Directing and Controlling.

CO4: Select the best economic model from various available alternatives.

CO5: Understand various interest rate methods and implement the suitable one.

CO6: Estimate various depreciation values of commodities.

CO7: Prepare the project reports effectively.

Question paper pattern:

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

Sl No	Title of the Book	Name of the	Name of the Publisher	Edition and
Textbook/s				
1	Mechanical estimation and costing	T.R. Banga & S.C. Sharma	Khanna Publishers	17th edition 2015
2	Engineering Economy	Riggs J.L	McGraw Hill	4th
3	Engineering Economy	Thuesen H.G	PHI	2002
4	Principles of Management	Tripathy and Reddy	Tata McGraw Hill	3rd edition 2006
Reference Books				
1	Management Fundamentals - Concepts, Application, Skill Development	Robers Lusier Thomson	Pearson Education	
2	Modern Economic Theory	Dr. K. K. Dewett& M. H. Navalur,	Chand Publications	
3	Economics: Principles of Economics	N Gregory Mankiw,	Cengage Learning	
4	Basics of Engineering Economy	Leland Blank & Anthony Tarquin	McGraw Hill Publication (India) Private Limited	

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

MANAGEMENT AND ECONOMICS

Course Code	**18ME51**	CIE Marks	40
Teaching Hours/Week (L:T:P)	2:2:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To help the students to understand the fundamental concepts and principles of management; the basic roles, skills, functions of management, various organizational structures and basic knowledge of marketing.
- To impart knowledge, with respect to concepts, principles and practical applications of Economics, which govern the functioning of a firm/organization under different market conditions.

Module-1

Management: Introduction - Meaning - nature and characteristics of Management, Scope and Functional areas of management - Management as a science, art of profession - Management & Administration - Roles of Management, Levels of Management, Development of Management Thought- early management approaches – Modern management approaches. Planning: Nature, importance and purpose of planning process Objectives - Types of plans (Meaning Only) - Decision making Importance of planning - steps in planning & planning premises - Hierarchy of plans.

Module-2

Organizing and Staffing: Nature and purpose of organization Principles of organization - Types of organization - Departmentation Committees Centralization Vs Decentralization of authority and responsibility - Span of control - MBO and MBE (Meaning Only) Nature and importance of staffing--Process of Selection & Recruitment (in brief). Directing & Controlling: Meaning and nature of directing Leadership styles, Motivation Theories, Communication - Meaning and importance - coordination, meaning and importance and Techniques of Co Ordination. Meaning and steps in controlling - Essentials of a sound control system - Methods of establishing control (in brief).

Module-3

Introduction: Engineering and economics, Problem solving and decision making, Laws of demand and supply, Difference between Microeconomics & Macroeconomics, equilibrium between demand & supply, elasticity of demand, price elasticity, income elasticity. Law of Returns, Interest and interest factors, simple and compound interest, Cash flow diagrams, personal loans and EMI payment calculation with flexible interest rates, Discussion and problems.

Module-4

Present, future and annual worth and rate of returns: Basic present worth comparisons, Present worth-equivalence, Assets with unequal lives and infinites lives, future worth comparisons, payback comparisons, Equivalent annual worth comparisons, situations for annual worth comparisons. Asset life, Rate of return, minimum acceptable rate of return, IRR anomalies and misconceptions, Cost of capital, comparisons of all present future and annual worth with IRR, product costing, Discussions and problems.

Module-5

Costing and depreciation: Components of costs, estimation of selling price, marginal cost, first cost, all kinds of overheads, indirect cost estimation with depreciation, mensuration and estimation of material cost, cost estimation of mechanical process, idling time. Product costing (approaches to product costing), causes of depreciation, methods of computing depreciation charges, straight line method, declining balance method, sum of years method, sinking fund method, service output methods, taxation concepts, personal income taxes and corporate taxes, Discussions and problems.

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

CO1: Understand needs, functions, roles, scope and evolution of Management

CO2: Understand importance, purpose of Planning and hierarchy of planning and also54nalyse its types.

CO3: Discuss Decision making, Organizing, Staffing, Directing and Controlling.

CO4: Select the best economic model from various available alternatives.
CO5: Understand various interest rate methods and implement the suitable one.
CO6: Estimate various depreciation values of commodities.
CO7: Prepare the project reports effectively.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the	Edition and Year
Textbook/s				
1	Mechanical estimation	T.R. Banga& S.C. Sharma	Khanna Publishers	17th edition
2	Engineering Economy	Riggs J.L	McGraw Hill	4th edition
3	Engineering Economy	Thuesen H.G	PHI	2002
4	Principles of Management	Tripathy and Reddy	Tata McGraw Hill	3rd edition 2006
Textbook/s				
1	Mechanical estimation	T.R. Banga& S.C. Sharma	Khanna Publishers	17th edition
2	Engineering Economy	Riggs J.L	McGraw Hill	4th edition
3	Engineering Economy	Thuesen H.G	PHI	2002
4	Principles of Management	Tripathy and Reddy	Tata McGraw Hill	3rd edition 2006

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

DESIGN OF MACHINE ELEMENTS I

Course Code	**18ME52**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:2:0	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To understand the various steps involved in the Design Process.
- To explain the principles involved in design of machine elements, subjected to different kinds of forces, from the considerations of strength, rigidity, functional and manufacturing requirements.
- To understand and interpret different failure modes and application of appropriate criteria for design of machine elements.
- To learn to use national and international standards, standard practices, standard data, catalogs, and standard components used in design of machine elements.
- Develop the capability to design elements like shafts, couplings, welded joints, screwed joints, and power screws.

Module-1

Introduction: Design Process: Definition of design, phases of design, and review of engineering materials and their properties and manufacturing processes; use of codes and standards, selection of preferred sizes.
Review of axial, bending, shear and torsion loading on machine components, combined loading, two- and three dimensional stresses, principal stresses, stress tensors, Mohr's circles.
Design for static strength: Factor of safety and service factor.
Failure mode: definition and types. , Failure of brittle and ductile materials; even and uneven materials; Theories of failure: maximum normal stress theory, maximum shear stress theory, distortion energy theory, strain energy theory, Columba –Mohr theory and modified Mohr's theory. Stress concentration, stress concentration factor and methods of reducing stress concentration.

Module-2

Impact Strength: Introduction, Impact stresses due to axial, bending and torsion loads.
Fatigue loading: Introduction to fatigue failure, Mechanism of fatigue failure, types of fatigue loading, S-N Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit.
Modifying factors: size effect, surface effect, Stress concentration effects Notch sensitivity, Soder berg and Goodman relationships, stresses due to combined loading, cumulative fatigue damage, and Miner's equation.

Module-3

Design of shafts: Torsion of shafts, solid and hollow shaft design with steady loading based on strength and rigidity, ASME and BIS codes for power transmission shafting, design of shafts subjected to combined bending, torsion and axial loading. Design of shafts subjected to fluctuating loads
Design of keys and couplings :Keys: Types of keys and their applications, design considerations in parallel and tapered sunk keys, Design of square and rectangular sunk keys.
Couplings: Rigid and flexible coupling-types and applications, design of Flange coupling, and Bush and Pin type coupling.

Module-4

Design of Permanent Joints: Types of permanent joints-Riveted and Welded Joints.
Riveted joints: Types of rivets, rivet materials, Caulking and fullering, analysis of riveted joints, joint efficiency, failures of riveted joints, boiler joints, riveted brackets.
Welded joints: Types, strength of butt and fillet welds, eccentrically loaded welded joints

Module-5

Design of Temporary Joints: Types of temporary joints- cotter joints, knuckle joint and fasteners. Design of Cotter and Knuckle Joint.
Threaded Fasteners: Stresses in threaded fasteners, effect of initial tension, design of threaded fasteners under static, dynamic and impact loads, design of eccentrically loaded bolted joints.

Power screws: Mechanics of power screw, stresses in power screws, efficiency and self-locking, design of power screws.

Assignment:

Course work includes a **Design project**. Design project should enable a group of students (maximum four in a group) to design a mechanical system (like couplings, screw jack, welded joints, bracket mounting using fasteners, etc.). Student should submit assembly drawing and part drawings, completely dimensioned, indicating the necessary manufacturing tolerances, surface finish symbols and geometric tolerances wherever necessary. Design project must be completed using appropriate solid modeling software. Computer generated drawings must be submitted. Design calculations must be hand written and should be included in the report. Design project should be given due credit in internal assessment.

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

CO1: Apply the concepts of selection of materials for given mechanical components.

CO2: List the functions and uses of machine elements used in mechanical systems.

CO3: Apply codes and standards in the design of machine elements and select an element based on the Manufacturer's catalogue.

CO4: Analyse the performance and failure modes of mechanical components subjected to combined loading and fatigue loading using the concepts of theories of failure.

CO5: Demonstrate the application of engineering design tools to the design of machine components like shafts, couplings, power screws, fasteners, welded and riveted joints.

CO6: Understand the art of working in a team.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the	Edition and Year
Textbook/s				
1	Shigley's Mechanical Engineering Design	Richard G. Budynas, and J. Keith Nisbett	McGraw-Hill Education	10th edition, 2015.
2	Fundamentals of Machine Component Design	Juvinall R.C, and Marshek K.M.	John Wiley & Sons	Third Edition, 2007 student
3	Design of Machine Elements,	V B Bhandari	Tata McGraw Hill	4th Ed., 2016.
4	Design of Machine Elements-I	Dr.M H Annaiah Dr. J Suresh Kumar	New Age International (P)	1s Ed., 2016
Reference Books				
1	Machine Design- an integrated approach	Robert L. Norton	Pearson Education	2nd edition.
2	Design and Machine Elements	Spotts M.F., Shoup T.E	Pearson Education	8th edition,2006
3	Machine Component Design	Orthwein W	Jaico Publishing Co	2003
4	Machine Design	Hall, Holowenko, Laughlin (Schaum's Outline series)	Tata McGraw Hill Publishing	Special Indian Edition, 2008
5	Elements of Machine Design	H.G.Patil, S.C.Pilli, R.R.Malagi, M.S.Patil	IK International	First edition,2019

6	Design of Machine Elements Volume I	T. Krishna Rao	IK international publishing house,	2012
7	Hand book of Mechanical Design	G. M. Maithra and L.V.Prasad	Tata McGraw Hill	2nd edition, 2004.

Design Data Hand Book:

[1] Design Data Hand Book, K. Lingaiah, McGraw Hill, 2nd edition, 2003.

[2] Design Data Hand Book, K. Mahadevan and Balaveera Reddy, CBS publication.

[3] Design Data Hand Book, H.G.Patil, I. K. International Publisher, 2010

[4] PSG Design Data Hand Book, PSG College of technology, Coimbatore.

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

DYNAMICS OF MACHINES

Course Code	**18ME53**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:2:0	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To understand the force-motion relationship in components subjected to external forces and analysis of standard mechanisms.
- To understand the undesirable effects of unbalances resulting from prescribed motions in mechanism.
- To understand the effect of Dynamics of undesirable vibrations.
- To understand the principles in mechanisms used for speed control and stability control.
- To know the concepts of modelling mechanical systems using spring, mass and damper elements.
- To compute the natural and damped frequencies of free 1-DOF mechanical systems
- To analyze the vibrational motion of 1-DOF mechanical systems under harmonic excitation conditions.

Module-1

Static force analysis: Static equilibrium, analysis of four bar mechanism, slider crank mechanism, shaper mechanism. **Dynamic force analysis:** D'Alembert's principle, analysis of four bar and slider crank mechanism, shaper mechanism.

Module-2

Balancing of Rotating Masses: Static and Dynamic Balancing, Balancing of single rotating mass by balancing masses in same plane and in different planes. Balancing of several rotating masses by balancing masses in same plane and in different planes.
Balancing of Reciprocating Masses: Inertia Effect of crank and connecting rod, Single cylinder Engine, Balancing in multi cylinder-inline engine (primary and secondary forces), V-type engine, Radial engine – direct and reverse crank method.

Module-3

Governors: Types of Governors; Force Analysis of Porter and Hartnell Governors. Controlling Force, Stability, Sensitiveness, Isochronism, Effort and Power.
Gyroscope: Vectorial representation of angular motion, Gyroscopic couple. Effect of gyroscopic Couple on plane disc, ship, aeroplane, Stability of two wheelers and four wheelers.

Module-4

Free vibrations: Basic elements of vibrating system, Types of free vibrations, Longitudinal vibrations-Equilibrium method, D'Alembert's principle, Energy method, Rayleigh's method. Determination of natural frequency of single degree freedom systems, Effect of spring mass, Damped free vibrations: Under damped, over damped and critically damped systems. Logarithmic decrement.

Module-5

Forced vibrations: Undamped forced vibration of spring mass system, Damped forced vibrations, Rotating unbalance, Reciprocating unbalance, Vibration isolation, Support motion(absolute and relative motion), Transverse vibration of shaft with single concentrated load, several loads, uniformly distributed load, Critical speed.

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

CO1: Analyse the mechanisms for static and dynamic equilibrium.

CO2: Carry out the balancing of rotating and reciprocating masses

CO3: Analyse different types of governors used in real life situation.

CO4: Analyse the gyroscopic effects on disks, airplanes, stability of ships, two and four wheelers

CO5: Understand the free and forced vibration phenomenon.

CO6: Determine the natural frequency, force and motion transmitted in vibrating systems.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Theory of Machines: Kinematics and Dynamics	Sadhu Singh	Pearson	Third edition 2019.
2	Mechanism and Machine Theory	G. Ambekar	PHI	2009
Reference Books				
1	Theory of Machines	Rattan S.S.	Tata McGraw-Hill Publishing Company	2014
2	Mechanisms and Machines-Kinematics, Dynamics and Synthesis	Michael M Stanisic	Cengage Learning	2016

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

TURBO MACHINES

Course Code	**18ME54**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand typical design of Turbo machine, their working principle, application and thermodynamics process involved.
- Study the conversion of fluid energy to mechanical energy in Turbo machine with utilization factor and degree of reaction.
- Analyse various designs of steam turbine and their working principle.
- Study the various designs of hydraulic turbine based on the working principle.
- Understand the various aspects in design of power absorbing machine.

Module-1

Introduction: Definition of turbo machine, parts of turbo machines, Comparison with positive displacement machines, Classification, Dimensionless parameters and their significance, Unit and specific quantities, model studies and its numerical.

(Note: Since dimensional analysis is covered in Fluid Mechanics subject, questions on dimensional analysis may not be given. However, dimensional parameters and model studies may be given more weightage.)

Thermodynamics of fluid flow: Application of first and second law of thermodynamics to turbo machines, Efficiencies of turbo machines, Static and Stagnation states, overall isentropic efficiency, stage efficiency (their comparison) and polytropic efficiency for both compression and expansion processes. Reheat factor for expansion process. Simple Numerical on stage efficiency and polytropic efficiency.

Module-2

Energy exchange in Turbo machines: Euler's turbine equation, Alternate form of Euler's turbine equation, Velocity triangles for different values of degree of reaction, Components of energy transfer, Degree of Reaction, utilization factor, Relation between degree of reaction and Utilization factor, Problems.

General Analysis of Turbo machines: Radial flow compressors and pumps – general analysis, Expression for degree of reaction, velocity triangles, Effect of blade discharge angle on energy transfer and degree of reaction, Effect of blade discharge angle on performance, , General analysis of axial flow pumps and compressors, degree of reaction, velocity triangles, Numerical Problems.

Module-3

Steam Turbines: Classification, Single stage impulse turbine, condition for maximum blade efficiency, stage efficiency, Need and methods of compounding, Multi-stage impulse turbine, expression for maximum utilization factor, Numerical Problems.

Reaction turbine – Parsons's turbine, condition for maximum utilization factor, reaction staging. Numerical Problems

Module-4

Hydraulic Turbines: Classification, various efficiencies.

Pelton Wheel – Principle of working, velocity triangles, design parameters, maximum efficiency, and numerical problems.

Francis turbine – Principle of working, velocity triangles, design parameters, and numerical problems

Kaplan and Propeller turbines - Principle of working, velocity triangles, design parameters and Numerical Problems. Theory and types of Draft tubes.

Module-5

Centrifugal Pumps: Classification and parts of centrifugal pump, different heads and efficiencies of centrifugal pump, Theoretical head – capacity relationship, Minimum speed for starting the flow, Maximum suction lift, Net positive suction head, Cavitation, Need for priming, Pumps in series and parallel. Problems.

Centrifugal Compressors: Stage velocity triangles, slip factor, power input factor, Stage work, Pressure developed, stage efficiency and surging and problems.

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

CO1: Model studies and thermodynamics analysis of turbomachines.

CO2: Analyse the energy transfer in Turbo machine with degree of reaction and utilisation factor.

CO3: Classify, analyse and understand various type of steam turbine.

CO4: Classify, analyse and understand various type of hydraulic turbine.

CO5: Understand the concept of radial power absorbing machine and the problems involved during its operation.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	An Introduction to Energy Conversion, Volume III, Turbo machinery	V. Kadambi and Manohar Prasad	New Age International Publishers	reprint 2008
2	Turbo Machines	B.U.Pai	Wiley India Pvt, Ltd	1st Edition
3	Turbo machines	M. S. Govindegowda and A. M. Nagaraj	M. M. Publications	7Th Ed, 2012
4	Fundamentals of Turbo Machinery	B.K Venkanna	PHI Publishers	
Reference Books				
1	Turbines, Compressors & Fans	S. M. Yahya	Tata McGraw Hill Co. Ltd	2nd edition, 2002
2	Principals of Turbo machines	D. G. Shepherd	The Macmillan Company	1964
3	Fluid Mechanics & Thermodynamics of Turbo machines	S. L. Dixon	Elsevier	2005

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

FLUID POWER ENGINEERING

Course Code	**18ME55**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To provide an insight into the capabilities of hydraulic and pneumatic fluid power.
- To understand concepts and relationships surrounding force, pressure, energy and power in fluid power systems.
- To examine concepts cantering on sources of hydraulic power, rotary and linear actuators, distribution systems, hydraulic flow in pipes, and control components in fluid power systems.
- Exposure to build and interpret hydraulic and pneumatic circuits related to industrial applications.
- To familiarize with logic controls and trouble shooting.

Module-1

Introduction to fluid power systems

Fluid power system: components, advantages and applications. Transmission of power at static and dynamic states. Pascal's law and its applications.

Fluids for hydraulic system: types, properties, and selection. Additives, effect of temperature and pressure on hydraulic fluid. Seals, sealing materials, compatibility of seal with fluids. Types of pipes, hoses, and quick acting couplings. Pressure drop in hoses/pipes. Fluid conditioning through filters, strainers; sources of contamination and contamination control; heat exchangers.

Module-2

Pumps and actuators

Pumps: Classification of pumps, Pumping theory of positive displacement pumps, construction and working of Gear pumps, Vane pumps, Piston pumps, fixed and variable displacement pumps, Pump performance characteristics, pump selection factors, problems on pumps.

Accumulators: Types, and applications of accumulators. Types of Intensifiers, Pressure switches /sensor, Temperature switches/sensor, Level sensor.

Actuators: Classification cylinder and hydraulic motors, Hydraulic cylinders, single and double acting cylinder, mounting arrangements, cushioning, special types of cylinders, problems on cylinders.

Construction and working of rotary actuators such as gear, vane, piston motors, and Hydraulic Motor. Theoretical torque, power, flow rate, and hydraulic motor performance; numerical problems. Symbolic

Module-3

Components and hydraulic circuit design Components:

Classification of control valves, Directional Control Valves-symbolic representation, constructional features of poppet, sliding spool, rotary type valves solenoid and pilot operated DCV, shuttle valve, and check valves.

Pressure control valves - types, direct operated types and pilot operated types.

Flow Control Valves -compensated and non-compensated FCV, needle valve, temperature compensated, pressure compensated, pressure and temperature compensated FCV, symbolic representation.

Hydraulic Circuit Design: Control of single and Double -acting hydraulic cylinder, regenerative circuit, pump unloading circuit, counter balance valve application, hydraulic cylinder sequencing circuits, hydraulic circuit for force multiplication; speed control of hydraulic cylinder- metering in, metering out and bleed off circuits. Pilot pressure operated circuits.

Module-4

Pneumatic power systems

Introduction to Pneumatic systems: Pneumatic power system, advantages, limitations, applications, Choice of working medium. Characteristics of compressed air and air compressors. Structure of pneumatic control System, fluid conditioners-dryers and FRL unit.

Pneumatic Actuators: Linear cylinder – types of cylinders, working, end position cushioning, seals, mounting arrangements, and applications. Rotary cylinders- types, construction and application, symbols.

Pneumatic Control Valves: DCV such as poppet, spool, suspended seat type slide valve, pressure control valves, flow control valves, types and construction, use of memory valve, Quick exhaust valve, time delay valve, shuttle valve, twin pressure valve, symbols.

Module-5

Pneumatic control circuits

Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, speed control of cylinders - supply air throttling and exhaust air throttling.

Signal Processing Elements: Use of Logic gates - OR and AND gates in pneumatic applications. Practical examples involving the use of logic gates.

Multi- Cylinder Application: Coordinated and sequential motion control, motion and control diagrams. Signal elimination methods, Cascading method- principle, Practical application examples (up to two cylinders) using cascading method (using reversing valves).

Electro- Pneumatic Control: Principles - signal input and output, pilot assisted solenoid control of directional control valves, use of relay and contactors. Control circuitry for simple signal cylinder application.

Learning Assignment:

The faculty will allocate one or more of the following experiments from group A and B to group of students (containing not more than four students in a group):

Group A: Experiments on hydraulic trainer:

a. Speed control circuit using metering in and metering out technique
b. Regenerative and sequencing circuits.
c. Extend-Retract and Stop system of a linear actuator
d. Rapid Traverse and Feed circuit.

Group B: Experiments on pneumatic trainer:

a. Automatic reciprocating circuit
b. Speed control circuit
c. Pneumatic circuit involving shuttle valve/ quick exhaust valve
d. Electro pneumatic valves and circuit

Students should build up the above circuits on computer using software and simulate the flow of fluid during the operation. Afterwards, they themselves can physically connect the circuit on the hydraulic/pneumatic trainer and run the circuit. Record of experiments shall be submitted in the form of journal. Due credit must be given for this assignment.

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

CO1: Identify and analyse the functional requirements of a fluid power transmission system for a given application.
CO2: Visualize how a hydraulic/pneumatic circuit will work to accomplish the function.
CO3: Design an appropriate hydraulic or pneumatic circuit or combination circuit like electro-hydraulics, electro- pneumatics for a given application.
CO4: Select and size the different components of the circuit.
CO5: Develop a comprehensive circuit diagram by integrating the components selected for the given application.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Fluid Power with applications	Anthony Esposito	Pearson edition	2000
2	Oil Hydraulics	Majumdar S.R	Tala McGRawHllL	2002
3	Pneumatic systems - Principles and Maintenance	Majumdar S.R	Tata McGraw-Hill	2005
Reference Books				
1	Industrial Hydraulics	John Pippenger, Tyler Hicks	McGraw Hill International Edition	1980
2	Hydraulics and pneumatics	Andrew Par	Jaico Publishing House	2005
3	Fundamentals of Pneumatics, Vol I, II and III.	FESTO		
4	Hydraulic Control Systems	Herbert E. Merritt	John Wiley and Sons, Inc	
5	Introduction to Fluid power	Thomson	PrentcieHall	2004
6	Fundamentals of fluid power control	John Watton	Cambridge University press	2012

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

OPERATIONS MANAGEMENT

Course Code	**18ME56**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To get acquainted with the basic aspects of Production Management.
- The expose the students to various aspects of planning, organising and controlling operations Management.
- To understand different operational issues in manufacturing and services organisations.
- To understand different problem-solving methodologies and Production Management techniques.

Module-1

Introduction, Functions within business organizations, the operation management function, Classification of production systems, Productivity, factors affecting productivity.

Decision Making: The decision process, characteristics of operations decisions, use of models, decision making environments, graphical linear programming, analysis and trade-offs.

Module-2

Forecasting: Steps in forecasting process, approaches to forecasting, forecasts based on judgment and opinion, analysis of time series data, accuracy and control of forecasts, choosing a forecasting technique, elements of a good forecast.

Module-3

Capacity & Location Planning: Importance of capacity decisions, defining and measuring capacity, determinants of effective capacity, determining capacity requirement, developing capacity alternatives, evaluating alternatives, Need for location decisions, nature of locations decisions, general procedure for making locations decisions, evaluating locations decisions, facilities layout – need for layout decisions, types of processing.

Module-4

Aggregate Planning & Master Scheduling: Aggregate planning – Nature and scope of aggregate planning, strategies of aggregate planning, techniques for aggregate planning – graphical and charting techniques, mathematical techniques. The master production schedule, Master scheduling process, Master scheduling methods.

Module-5

Material Requirement Planning (MRP): Dependent versus independent demand, an overview of MRP – MRP inputs and outputs, MRP processing, ERP capacity requirement planning, benefits and limitations of MRP.

Purchasing and Supply Chain Management (SCM): Introduction, Importance of purchasing and SCM, the procur process, Concept of tenders, Approaches to SCM, Vendor development.

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

CO1: Explain the concept and scope of operations management in a business context
CO2: Recognize the role of Operations management among various business functions and its role in the organizations' strategic planning and gaining competitive advantage.
CO3: Analyze the appropriateness and applicability of a range of operations management systems/models in decision making.
CO4: Assess a range of strategies for improving the efficiency and effectiveness of organizational operations.
CO5: Evaluate a selection of frameworks used in the design and delivery of operations

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.

- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbooks:

1. "Operation Management, Author- Joseph G Monks McGrew Hill Publication, International Edition-1987.
2. "Production and Operation Management" ,Author-Pannerselvam R. PHI publications, 2nd edition
3. "An Introductory book on lean System, TPS Yasuhiro Modern.

Reference Books:

1. "Production and Operation Management" Chary S. N. TataMcGrew Hill 3rd edition.
2. "Production and Operations Management", Everett E. Adams, Ronald J. Ebert, Prentice Hall of India Publications, Fourth Edition.
3. Modern Production/Operations Management, Buffia, Wiely India Ltd 4th Edition.

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER –V

FLUID MECHANICS AND MACHINES LAB

Course Code	**18MEL57**	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- This course will provide a basic understanding of flow measurements using various types of flow measuring devices, calibration and losses associated with these devices.
- Energy conversion principles, analysis and understanding of hydraulic turbines and pumps will be discussed. Application of these concepts for these machines will be demonstrated. Performance analysis will be carried out using characteristic curves.

Sl. No.	Experiments
	PART A
1	Lab layout, calibration of instruments and standards to be discussed
2	Determination of coefficient of friction of flow in a pipe.
3	Determination of minor losses in flow through pipes.
4	Application of momentum equation for determination of coefficient of impact of jets on flat and curved blades
5	Calibration of flow measuring devices.
	PART B
6	Performance on hydraulic Turbines a. Pelton wheel b. Francis Turbine c. Kaplan Turbines
7	Performance hydraulic Pumps d. Single stage and Multi stage centrifugal pumps e. Reciprocating pump.
8	Performance test on a two stage Reciprocating Air Compressor.
9	Performance test on an Air Blower.
	PART C (OPTIONAL)
10	Visit to Hydraulic Power station/ Municipal Water Pump House and Case Studies
11	Demonstration of cut section models of Hydraulic turbines and Pumps.

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

CO1: Perform experiments to determine the coefficient of discharge of flow measuring devices.
CO2: Conduct experiments on hydraulic turbines and pumps to draw characteristics.
CO3: Test basic performance parameters of hydraulic turbines and pumps and execute the knowledge in real life situations.
CO4: Determine the energy flow pattern through the hydraulic turbines and pumps.
CO5: Exhibit his competency towards preventive maintenance of hydraulic machines.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Scheme of Examination:

ONE question from part A: 30 Marks
ONE question from part B: 50 Marks
Viva –Voice : 20 Marks
Total : 100 Marks

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER –V

ENERGY CONVERSION LABORATORY

Course Code	**18MEL58**	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- This course will provide a basic understanding of fuel properties and its measurements using various types of measuring devices
- Energy conversion principles, analysis and understanding of I C Engines will be discussed. Application of these concepts for these machines will be demonstrated. Performance analysis will be carried out using characteristic curves.
- Exhaust emissions of I C Engines will be measured and compared with the standards.

Sl. No.	Experiments
	PART A
1	Lab layout, calibration of instruments and standards to be discussed
2	Determination of Flash point and Fire point of lubricating oil using Abel Pensky and Marten's (closed) / Cleveland's (Open Cup) Apparatus.
3	Determination of Calorific value of solid, liquid and gaseous fuels.
4	Determination of Viscosity of lubricating oil using Redwoods, Saybolt and Torsion Viscometers.
5	Valve Timing/port opening diagram of an I.C. Engine.
	PART B
6	Performance Tests on I.C. Engines, Calculations of IP, BP, Thermal efficiency, Volumetric efficiency, Mechanical efficiency, SFC, FP, A:F Ratio, heat balance sheet for a. Four stroke Diesel Engine b. Four stroke Petrol Engine c. Multi Cylinder Diesel/Petrol Engine, (Morse test) d. Two stroke Petrol Engine Variable Compression Ratio I.C. Engine.
7	Measurements of Exhaust Emissions of Petrol engine.
8	Measurements of Exhaust Emissions of Diesel engine.
	PART C (OPTIONAL)
9	Visit to Automobile Industry/service stations.
10	Demonstration of $p\theta$, pV plots using Computerized IC engine test rig

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

CO1: Perform experiments to determine the properties of fuels and oils.
CO2: Conduct experiments on engines and draw characteristics.
CO3: Test basic performance parameters of I.C. Engine and implement the knowledge in industry.
CO4: Identify exhaust emission, factors affecting them and exhibit his competency towards preventive maintenance of IC engines.

Scheme of Examination:

ONE question from part A: 30 Marks
ONE question from part B: 50 Marks
Viva –Voice : 20 Marks
Total : 100 Marks

B. E. MECHANICAL ENGINEEING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – V

ENVIRONMENTAL STUDIES

Course Code	**18CIV59**	CIE Marks	40
Teaching Hours / Week (L:T:P)	(1:0:0)	SEE Marks	60
Credits	01	Exam Hours	02

Module - 1

Ecosystems (Structure and Function): Forest, Desert, Wetlands, Riverine, Oceanic and Lake. 02 Hrs
Biodiversity: Types, Value; Hot-spots; Threats and Conservation of biodiversity, Forest Wealth, and Deforestation.

Module - 2

Advances in Energy Systems (Merits, Demerits, Global Status and Applications)**:** Hydrogen, Solar, OTEC, Tidal and Wind. 02 Hrs
Natural Resource Management (Concept and case-studies): Disaster Management, Sustainable Mining, Cloud Seeding, and Carbon Trading.

Module - 3

Environmental Pollution (Sources, Impacts, Corrective and Preventive measures, Relevant Environmental Acts, Case-studies)**:** Surface and Ground Water Pollution; Noise pollution; Soil Pollution and Air Pollution.02 Hrs
Waste Management & Public Health Aspects: Bio-medical Wastes; Solid waste; Hazardous wastes; E-wastes; Industrial and Municipal Sludge.

Module - 4

Global Environmental Concerns (Concept, policies and case-studies): Ground water depletion/recharging, Climate Change; Acid Rain; Ozone Depletion; Radon and Fluoride problem in drinking water; Resettlement and rehabilitation of people, Environmental Toxicology.

Module - 5

Latest Developments in Environmental Pollution Mitigation Tools (Concept and Applications): G.I.S. & Remote Sensing, Environment Impact Assessment, Environmental Management Systems, ISO14001; Environmental Stewardship- NGOs. 03 Hrs
Field work: Visit to an Environmental Engineering Laboratory or Green Building or Water Treatment Plant or Waste water treatment Plant; ought to be Followed by understanding of process and its brief documentation.

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

- CO1: Understand the principles of ecology and environmental issues that apply to air, land, and water issues on a global scale,
- CO2: Develop critical thinking and/or observation skills, and apply them to the analysis of a problem or question related to the environment.
- CO3: Demonstrate ecology knowledge of a complex relationship between biotic and abiotic components.
- CO4: Apply their ecological knowledge to illustrate and graph a problem and describe the realities that managers face when dealing with complex issues.

Question paper pattern:

- The Question paper will have 100 objective questions.
- Each question will be for 01 marks
- Student will have to answer all the questions in an OMR Sheet.
- The Duration of Exam will be 2 hours.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Environmental Studies	Benny Joseph	Tata Mc Graw – Hill.	2nd Edition, 2012

2.	Environmental Studies	S M Prakash	Pristine Publishing House, Mangalore	3rd Edition, 2018
3	Environmental Studies – From Crisis to Cure	R Rajagopalan	Oxford Publisher	2005
Reference Books				
1	Principals of Environmental Science and Engineering	Raman Sivakumar	Cengage learning, Singapur.	2nd Edition, 2005
2	Environmental Science – working with the Earth	G.Tyler Miller Jr.	Thomson Brooks /Cole,	11th Edition, 2006
3	Text Book of Environmental and Ecology	Pratiba Sing, AnoopSingh& Piyush Malaviya	Acme Learning Pvt. Ltd. New Delhi.	1st Edition

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

FINITE ELEMENT METHODS

Course Code	**18ME61**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:2:0	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To learn the basic principles of finite element analysis procedure
- To understand the design and heat transfer problems with application of FEM.
- Solve 1 D, 2 D and dynamic problems using Finite Element Analysis approach.
- To learn the theory and characteristics of finite elements that represent engineering structures.
- To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

Module-1

Introduction to Finite Element Method: General steps of the finite element method. Engineering applications of finite element method. Advantages of the Finite Element Method.
Boundary conditions: Homogeneous and non-homogeneous for structural, heat transfer and fluid flow problems. Potential energy method, Rayleigh Ritz method, Galerkin's method, Displacement method of finite element formulation. Convergence criteria, Discretisation process, **Types of elements:** 1D, 2D and 3D, Node numbering, Location of nodes. **Strain-** displacement relations, Stress-strain relations, Plain stress and Plain strain conditions, temperature effects.
Interpolation models: Simplex, complex and multiplex elements, linear interpolation polynomials in terms of global coordinates 1D, 2D, 3D Simplex Elements.

Module-2

Introduction to the stiffness (Displacement) method: Introduction, Derivation of stiffness matrix, Derivation of stiffness matrix for a spring element, Assembly the total stiffness matrix by superposition. One-Dimensional Elements-Analysis of Bars and Trusses, Linear interpolation polynomials in terms of local coordinate's for1D, 2Delements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, , , Constant strain triangle, Four-Nodded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element (HEXA 3 8), 2D iso-parametric element, Lagrange interpolation functions.
Numerical integration: Gaussian quadrature one point, two point formulae, 2D integrals. Force terms: Body force, traction force and point loads, Numerical Problems: Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach. Analysis of

Module-3

Beams and Shafts: Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory, Examples on cantilever beams, propped cantilever beams, Numerical problems on simply supported, fixed straight and stepped beams using direct stiffness method with concentrated and uniformly distributed load.
Torsion of Shafts: Finite element formulation of shafts, determination of stress and twists in circular shafts.

Module-4

Heat Transfer: Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, 1D finite element formulation using vibration method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins.
Fluid Flow: Flow through a porous medium, Flow through pipes of uniform and stepped sections, Flow through hydraulic net works.

Module-5

Axi-symmetric Solid Elements: Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to surface forces, point loads, angular velocity, pressure vessels.

Dynamic Considerations: Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axisymmetric triangular element, quadrilateral element, beam element. Lumped mass matrix of bar element, truss element, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

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

CO1: Identify the application and characteristics of FEA elements such as bars, beams, plane and iso-parametric elements.

CO2: Develop element characteristic equation and generation of global equation.

CO3: Formulate and solve Axi-symmetric and heat transfer problems.

CO4: Apply suitable boundary conditions to a global equation for bars, trusses, beams, circular shafts, heat transfer, fluid flow, axi-symmetric and dynamic problems

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	A first course in the Finite Element Method	Logan, D. L	Cengage Learning	6th Edition 2016
2	Finite Element Method in Engineering	Rao, S. S	Pergaman Int. Library of Science	5th Edition 2010
3	Finite Elements in Engineering	Chandrupatla T. R	PHI	2nd Edition 2013
Reference Books				
1	Finite Element Method	J.N.Reddy	McGraw -Hill International Edition	
2	Finite Elements Procedures	Bathe K. J	PHI	
3	Concepts and Application of Finite Elements Analysis	Cook R. D., et al.	Wiley & Sons	4th Edition 2003

E- Learning

• VTU, E- learning

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

DESIGN OF MACHINE ELEMENTS II

Course Code	**18ME62**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:2:0	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To understand various elements involved in a mechanical system.
- To analyze various forces acting on the elements of a mechanical system and design them using appropriate techniques, codes, and standards.
- To select transmission elements like gears, belts, pulleys, bearings from the manufacturers' catalogue.
- To design a mechanical system integrating machine elements.
- To produce assembly and working drawings of various mechanical systems involving machine elements like belts, pulleys, gears, springs, bearings, clutches and brakes.

Module-1

Springs: Types of springs, spring materials, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, concentric springs; springs under fluctuating loads.
Leaf Springs: Stresses in leaf springs, equalized stresses, and nipping of leaf springs.
Introduction to torsion and Belleville springs.
Belts: Materials of construction of flat and V belts, power rating of belts, concept of slip and creep, initial tension, effect of centrifugal tension, maximum power condition.
Selection of flat and V belts- length & cross section from manufacturers' catalogues. Construction and application of timing belts.
Wire ropes: Construction of wire ropes, stresses in wire ropes, and selection of wire ropes.

Module-2

Gear drives: Classification of gears, materials for gears, standard systems of gear tooth, lubrication of gears, and gear tooth failure modes.
Spur Gears: Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear.
Helical Gears: Definitions, transverse and normal module, formative number of teeth, design based on strength, dynamic load and wear.

Module-3

Bevel Gears: Definitions, formative number of teeth, design based on strength, dynamic load and wear.
Worm Gears: Definitions, types of worm and worm gears, and materials for worm and worm wheel. Design based on strength, dynamic, wear loads and efficiency of worm gear drives.

Module-4

Design of Clutches: Necessity of a clutch in an automobile, types of clutch, friction materials and its properties. Design of single plate, multi-plate and cone clutches based on uniform pressure and uniform wear theories.
Design of Brakes: Different types of brakes, Concept of self-energizing and self-locking of brakes. Practical examples, Design of band brakes, block brakes and internal expanding brakes.

Module-5

Lubrication and Bearings: Lubricants and their properties, bearing materials and properties; mechanisms of lubrication, hydrodynamic lubrication, pressure development in oil film, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, and heat dissipated. Numerical examples on hydrodynamic journal and thrust bearing design.

Antifriction bearings: Types of rolling contact bearings and their applications, static and dynamic load carrying capacities, equivalent bearing load, load life relationship; selection of deep grove ball bearings from the manufacturers' catalogue; selection of bearings subjected to cyclic loads and speeds;probability of survival.

Assignment:

Course work includes a **Design project**. Design project should enable the students to design a mechanical system (like single stage reduction gear box with spur gears, single stage worm reduction gear box, V-belt and pulley drive system, machine tool spindle with bearing mounting, C-clamp, screw jack, etc.) A group of students (maximum number in a group should be 4) should submit assembly drawing and part drawings, completely dimensioned, indicating the necessary manufacturing tolerances, surface finish symbols and geometric tolerances wherever necessary. Design project must be completed using appropriate solid modeling software. Computer generated drawings must be submitted. Design calculations must be hand written and should be included in the report. Design project should be given due credit in internal assessment.

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

CO1: Apply design principles for the design of mechanical systems involving springs, belts, pulleys, and wire ropes.
CO2: Design different types of gears and simple gear boxes for relevant applications.
CO3: Understand the design principles of brakes and clutches.
CO4: Apply design concepts of hydrodynamic bearings for different applications and select Anti friction bearings for different applications using the manufacturers, catalogue.
CO6: Apply engineering design tools to product design.
CO7: Become good design engineers through learning the art of working in a team.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Shigley's Mechanical Engineering Design	Richard G. Budynas,and J. Keith Nisbett	McGraw-Hill Education	10th Edition, 2015
2	Fundamentals of Machine Component Design	Juvinall R.C, and Marshek K.M	John Wiley & Sons	Third Edition 2007 Wiley student edition
3	Design of Machine Elements	V. B. Bhandari	Tata Mcgraw Hill	4th Ed 2016.
4	Design of Machine Elements-II	Dr.M H Annaiah Dr. J Suresh Kumar Dr.C N Chandrappa	New Age International (P) Ltd.,	1s Ed., 2016
Reference Books				
1	Machine Design- an integrated approach	Robert L. Norton	Pearson Education	2nd edition
2	Design and Machine Elements	Spotts M.F., ShoupT.E	Pearson Education	8th edition, 2006

3	Machine design Hall, Holowenko, Laughlin (Schaum's Outline Series	adapted by S.K.Somani	Tata McGraw Hill Publishing Company Ltd	Special Indian Edition, 2008
4	Elements of Machine Design	H.G.Patil, S.C.Pilli, R.R.Malagi, M.S.Patil	IK International	First edition,2019
5	Design of Machine ElementsVolume II	T. Krishna Rao	IK international publishing house	2013
6	Hand book of Mechanical Design	G. M. Maithra and L.V.Prasad	Tata McGraw Hill	2nd edition,2004

Design Data Hand Books:

[1] Design Data Hand Book, K.Lingaiah, McGraw Hill, 2nd edition, 2003.
[2] Design Data Hand Book, K.Mahadevan and Balaveera Reddy, CBS publication.
[3] Design Data Hand Book, H.G.Patil, I.K.International Publisher, 2010
[4] PSG Design Data Hand Book, PSG College of technology, Coimbatore

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

HEAT TRANSFER

Course Code	**18ME63**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:2:0	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- Study the modes of heat transfer.
- Learn how to formulate and solve 1-D steady and unsteady heat conduction problems.
- Apply empirical correlations for fully-developed laminar, turbulent internal flows and external boundary layer convective flow problems.
- Study the basic principles of heat exchanger analysis and thermal design.
- Understand the principles of boiling and condensation including radiation heat transfer related engineering problems.

Module-1

Introductory concepts and definitions: Modes of heat transfer: Basic laws governing conduction, convection, and radiation heat transfer; Types of boundary conditions. General three dimensional Heat Conduction Equation: Derivation of the equation in (i) Cartesian, coordinate only. Discussion of three dimensional Heat Conduction Equation in (ii) Polar and (iii) Spherical Co-ordinate Systems.

Steady-state one-dimensional heat conduction problems in Cartesian System: Steady-state one-dimensional heat conduction problems (i) without heat generation and (ii) constant thermal conductivity - in Cartesian system with various possible boundary conditions. Brief Introduction to variable thermal conductivity and heat generation [No numerical on variable thermal conductivity and heat generation] Thermal Resistances in Series and in Parallel. Critical Thickness of Insulation in cylinder and spheres Concept. Derivation

Module-2

Extended Surfaces or Fins: Classification, Straight Rectangular and Circular Fins, Temperature Distribution and Heat Transfer Calculations, Fin Efficiency and Effectiveness, Applications

Transient [Unsteady-state] heat conduction: Definition, Different cases - Negligible internal thermal resistance, negligible surface resistance, comparable internal thermal and surface resistance, Lumped body, Infinite Body and Semi-infinite Body, Numerical Problems, Heisler and Grober charts.

Module-3

Numerical Analysis of Heat Conduction: Introduction, one-dimensional steady conduction and one dimensional unsteady conduction, boundary conditions, solution methods.

Thermal Radiation: Fundamental principles - Gray, White, Opaque, Transparent and Black bodies, Spectral emissive power, Wien's displacement law, Planck's laws, Hemispherical Emissive Power, Stefan-Boltzmann law for the total emissive power of a black body, Emissivity and Kirchhoff's Laws, View factor, Net radiation exchange between parallel plates, concentric cylinders, and concentric spheres, Radiation Shield.

Module-4

Forced Convection: Boundary Layer Theory, Velocity and Thermal Boundary Layers, Prandtl number, Turbulent flow, Various empirical solutions, Forced convection flow over cylinders and spheres, Internal flows –laminar and turbulent flow solutions.

Free convection: Laminar and Turbulent flows, Vertical Plates, Vertical Tubes and Horizontal Tubes, Empirical solutions.

Module-5

Heat Exchangers: Definition, Classification, applications, LMTD method, Effectiveness - NTU method, Analytical Methods, Fouling Factors, Chart Solution Procedures for solving Heat Exchanger problems: Correction Factor Charts and Effectiveness-NTU Charts.

Introduction to boiling: pool boiling, Bubble Growth Mechanisms, Nucleate Pool Boiling, Critical Heat Flux in Nucleate Pool Boiling, Pool Film Boiling, Critical Heat Flux, Heat Transfer beyond the Critical Point, filmwise and dropwise Condensation.

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

CO1: Understand the modes of heat transfer and apply the basic laws to formulate engineering systems.

CO2: Understand and apply the basic laws of heat transfer to extended surface, composite material and unsteady state heat transfer problems.

CO3: Analyze heat conduction through numerical methods and apply the fundamental principle to solve radiation heat transfer problems.

CO4: Analyze heat transfer due to free and forced convective heat transfer.

CO5: Understand the design and performance analysis of heat exchangers and their practical applications, Condensation and Boiling phenomena.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Principals of heat transfer	Frank Kreith, Raj M. Manglik, Mark S. Bohn	Cengage learning	Seventh Edition 2011.
2	Heat transfer, a practical approach	Yunus A. Cengel	Tata Mc Graw Hill	Fifth edition
Reference Books				
1	Heat and mass transfer	Kurt C, Rolle	Cengage learning	second edition
2	Heat Transfer A Basic Approach	M. NecatiOzisik	McGraw Hill, New York	2005
3	Fundamentals of Heat and Mass Transfer	Incropera, F. P. and De Witt, D. P	John Wiley and Sons, New York	5th Edition 2006
4	Heat Transfer	Holman, J. P.	Tata McGraw Hill, New York	9th Edition 2008

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VI
Professional Elective- 1

NON-TRADITIONAL MACHINING

Course Code	**18ME641**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To learn various concepts related to modern machining processes & their applications.
- To appreciate the differences between conventional and non-conventional machining processes.
- To acquire a functional understanding of non-traditional manufacturing equipment.
- To know about various process parameters and their influence on performance and their applications.
- To impart knowledge on various types of energy involved in non-traditional machining processes.

Module-1

Introduction to Non-traditional machining, Need for Non-traditional machining process, Comparison between traditional and non-traditional machining, general classification Non-traditional machining processes, classification based on nature of energy employed in machining, selection of non-traditional machining processes, Specific advantages, limitations and applications of non-traditional machining processes.

Module-2

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.

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.

Module-3

ELECTROCHEMICAL 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.

Module-4

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.

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.

Module-5

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.

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

CO1: Understand the compare traditional and non-traditional machining process and recognize the need for Non- traditional machining process.

CO2: Understand the constructional features, performance parameters, process characteristics, applications, advantages and limitations of USM, AJM and WJM.

CO3: Identify the need of Chemical and electro-chemical machining process along with the constructional features, process parameters, process characteristics, applications, advantages and limitations.

CO4: Understand the constructional feature of the equipment, process parameters, process characteristics, applications, advantages and limitations EDM & PAM.

CO5: Understand the LBM equipment, LBM parameters, and characteristics. EBM equipment and mechanism of metal removal, applications, advantages and limitations LBM & EBM.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Modern Machining Process	by P.C Pandey and H S Shah	McGraw Hill Education India Pvt. Ltd.	2000
2	Production technology	HMT	McGraw Hill Education India Pvt. Ltd	2001
Reference Books				
1	New Technology	Dr. Amitabha Bhattacharyya	The Institute of Engineers (India)	2000
2	Modern Machining process	Aditya		2002

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VI
Professional Elective- 1

REFRIGERATION AND AIR CONDITIONING

Course Code	**18ME642**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Study the basic definition, ASHRAE Nomenclature for refrigerating systems.
- Understand the working principles and applications of different types of refrigeration systems.
- Study the working of air conditioning systems and their applications.
- Identify the performance parameters and their relations of an air conditioning system.

Module-1

Introduction to Refrigeration –Basic Definitions, ASHRAE Nomenclature, Air Refrigeration Cycles-reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems-merits and demerits and applications: Aircraft refrigeration cycles, Joule Thompson coefficient and Inversion Temperature, Linde, Claude and Stirling cycles for liquefaction of air.

Industrial Refrigeration-Chemical and process industries, Dairy plants , Petroleum refineries, Food processing and food chain, Miscellaneous

Module-2

Vapour Compression Refrigeration System(VCRS): Comparison of Vapour Compression Cycle and Gas cycle, Vapour Compression Refrigeration system Working and analysis, Limitations, Superheat horn and throttling loss for various refrigerants, efficiency, Modifications to standard cycle – liquid-suction heat exchangers, Grindlay cycle and Lorenz cycle, Optimum suction condition for optimum COP Actual cycles with pressure drops, Complete Vapour Compression Refrigeration System, Multi-Pressure, Multi-evaporator systems or Compound Vapour Compression Refrigeration Systems – Methods like Flash Gas removal, Flash inter cooling and water Inter cooling.

Module-3

Vapour Absorption Refrigeration Systems: Absorbent – Refrigerant combinations, Water-Ammonia Systems,Practical problems, Lithium- Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyzer Assembly.Practical problems – crystallization and air leakage, Commercial systems

Other types of Refrigeration systems: Brief Discussion on (i) Steam-Jet refrigeration system and (ii) Thermoelectric refrigeration, pulse tube refrigeration, thermoacoustic refrigeration systems

Module-4

Refrigerants: Primary and secondary refrigerants, Designation of Refrigerants, Desirable properties of refrigerants including solubility in water and lubricating oil, material compatibility, toxicity, flammability, leak detection, cost, environment and performance issues Thermodynamic properties of refrigerants, Synthetic and natural refrigerants, Comparison between different refrigerants vis a vis applications, Special issues and practical implications Refrigerant mixtures – zeotropic and azeotropic mixtures

Refrigeration systems Equipment: Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system.

Module-5

Air-Conditioning: Introduction to Air-Conditioning, Basic Definition, Classification, power rating, Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Different Air-Conditioning Systems-Central – Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air-Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning Systems.

Transport air conditioning Systems:Air conditioning systems for automobiles (cars, buses etc.), Air conditioning systems for trains, Air conditioning systems for ships

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

CO1: Illustrate the principles, nomenclature and applications of refrigeration systems.
CO2: Explain vapour compression refrigeration system and identify methods for performance improvement
CO3: Study the working principles of air, vapour absorption, thermoelectric and steam-jet and thermoacoustic refrigeration systems.
CO4: Estimate the performance of air-conditioning systems using the principles of psychrometry.
CO5: Compute and Interpret cooling and heating loads in an air-conditioning system.
CO6: Identify suitable refrigerant for various refrigerating systems.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Refrigeration and Air-conditioning	Arora C.P	Tata Mc Graw –Hill, New Delhi	2nd Edition, 2001
2	Principles of Refrigeration	Roy J. Dossat	Wiley Limited	
3	Refrigeration and Air-conditioning	Stoecker W.F., and Jones J.W.,	Mc Graw - Hill, New Delhi	2nd edition, 1982.
Reference Books				
1	Heating, Ventilation and Air Conditioning	McQuistion	Wiley Students edition	5th edition2000.
2	Air conditioning	PITA	Pearson	4th edition 2005
3	Refrigeration and Air-Conditioning	S C Arora& S Domkundwar	Dhanpat Rai Publication	
4	Principles of Refrigeration	Dossat	Pearson	2006
5	Refrigeration and Air-Conditioning	Manohar prasad		
6	Handbook of Air Conditioning and Refrigeration	Shan K. Wang	McGraw-Hill Education	2/e,2001

Data Book:

1. Mathur M.L. & Mehta,Refrigerant and Psychrometric Properties (Tables & Charts) SI Units, F.S., Jain Brothers,2008

E- Learning

- http://nptel.ac.in/courses/112105128/#

E-Resources

- VTU, E- learning, MOOCS, Open courseware

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VI
Professional Elective- 1

THEORY OF ELASTICITY

Course Code	**18ME643**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To provide the student with the mathematical and physical principles of Theory of Elasticity.
- To provide the student with various solution strategies while applying them to practical cases.

Module-1

Analysis of Stress: Definition and notation of stress, Equations of equilibrium in differential form, Stress components on an arbitrary plane, Equality of cross shear, Stress invariants, Principal stresses, Octahedral stress, Planes of maximum shear, Stress transformation, Plane state of stress, Mohr's diagram for 3dimensional state of stress.

Module-2

Analysis of Strain: Displacement field, Strains in term of displacement field, Infinitesimal strain at a point, Engineering shear strains, Strain invariants, Principal strains, Octahedral strains, Plane state of strain, Compatibility equations, Strain transformation. Principle of super position, Saint Venant principle.

Module-3

Two-Dimensional classical elasticity: Cartesian co-ordinates, Relation between plane stress and plane strain, stress functions for plane stress and plane strain state, Airy's stress functions, investigation of Airy's stress function for simple beams. Bending of a narrow cantilever beam of rectangular cross section under edge load. Bending of simply supported beam under UDL, stress concentration, stress distribution in an infinite plate with a circular hole subjected to uniaxial and biaxial loads.
General equations in polar coordinates, stress distribution symmetrical about an axis, Thick wall cylinder subjected to internal and external pressures.

Module-4

Stress analysis in Axisymmetric body: Stresses in rotating discs of uniform thickness and cylinders. Numerical Problems.
Torsion: Torsion of circular, elliptical and triangular bars, Prandtl's membrane analogy, Torsion of thin walled thin tubes, Torsion of thin walled multiple cell closed sections.

Module-5

Thermal stress: Thermo elastic stress strain relations, equations of equilibrium, thermal stresses in thin circular discs and in long circular cylinders.

Course Outcomes: At the end of the course, the student will be able to:
CO1: Understand the Basic field equations of linear elastic solids, force, stress, strain and equilibrium in solids.
CO2: Analyse the 2D structural elements, beams, cylinders.
CO3: Use analytical techniques to predict deformation, internal force and failure of simple solids and structural components.
CO4: Analyse the axisymmetric structural elements.
CO5: Analyse the structural members subjected to torsion
CO6: Determine the thermal stresses in plain stress and plane stain conditions.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Theory of Elasticity	S. P. Timoshenko and J. N Gordier	Mc-Graw Hill International	3rd edition, 2010
2	Advanced Mechanics of solids	L. S. Srinath	Tata Mc. Graw Hill	2009
Reference Books				
1	Theory of Elasticity	Sadhu Singh	Khanna Publications	2004
2	Applied Elasticity	T.G. Seetharamuand Govindaraju	Interline Publishing	2008.

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VI
Professional Elective- 1

VIBRATIONS AND NOISE ENGINEERING

Course Code	**18ME644**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To enable the students to understand the theoretical principles of vibration and vibration analysis techniques for the practical solution of vibration problems.
- To enable the students to understand the importance of vibrations in mechanical design of machine parts subject to vibrations
- To make free and forced (harmonic, periodic, non-periodic) vibration analysis of single and multi-degree of freedom linear systems.
- Be able to write the differential equation of motion of vibratory systems.

Module-1

Forced vibrations (1DOF): Introduction, analysis of forced vibration with constant harmonic excitation, MF, rotating and reciprocating unbalances, excitation of support (Relative and absolute amplitudes), force and motion transmissibility, energy dissipated due to damping and numerical problems.
Systems with 2DOF: Principal modes of vibrations, normal mode and natural frequencies of systems (Damping is not included), simple spring-mass systems, masses on tightly stretched strings, double pendulum, tensional systems, combined rectilinear and angular systems, geared systems and numerical problems.

Module-2

Numerical methods for multi DOF systems: Maxwell's reciprocal theorem, influence coefficients, Rayleigh's method, Dunkerley's method, stodola method, orthogonality principle, method of matrix iteration and numerical.
Modal analysis and condition monitoring: signal analysis, dynamic testing of machines and structures,

Module-3

Vibration measuring instruments and whirling of shafts: seismic instruments, vibrometers, accelerometer, frequency measuring instruments and numerical. Whirling of shafts with and without damping.
Vibration Control: Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, vibration isolation, Dynamic vibration absorbers and Vibration dampers.

Module-4

Transient Vibration of single Degree-of freedom systems: Impulse excitation, arbitrary excitation, Laplace transforms formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation.
Noise Engineering: Subjective response of sound: Frequency and sound dependent human response; the decibel scale; relationship between , sound pressure level(SPL), sound power level and sound intensity scale; relationship between addition, subtraction and averaging, sound spectra and Octave band analysis ; loudness; weighting networks; equivalent sound level, auditory effects of noise; hazardous noise, exposure due to machines and equipment; hearing conservation and damage risk criteria, daily noise doze.

Module-5

Noise: Sources, Isolation and control: Major sources of noise on road and in industries, noise due to construction equipment and domestic appliances, industrial noise control, strategies-noise control at source (with or without sound enclosures), noise control along the path (with or without partitions and acoustic barriers); noise control at the receiver, ear defenders, earplugs, semi-insert protectors.

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

CO1: Characterize the single and multi-degrees of freedom systems subjected to free and forced vibrations with and without damping.

CO2: Apply the method of vibration measurements and its controlling.

CO3: Determine vibratory responses of SDOF and MDOF systems to harmonic, periodic and non-periodic excitation.

CO4: Analyze the mathematical model of a linear vibratory system to determine its response.

CO5: Obtain linear mathematical models of reallife engineering systems.

CO6: Apply the principles of vibration and noise reduction techniques to real life engineering problems.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Mechanical Vibrations	S. S. Rao	Pearson Education	
2	Fundamentals of Mechanical Vibration	S. Graham Kelly	McGraw-Hill	
3	Mechanical Vibrations	W.T. Thomson	Prentice Hill India	
4	Vibraitons and Acoustics – Measurements and signal	C Sujatha	Tata McGraw Hill	
Reference Books				
1	Mechanical Vibrations	G. K. Grover	Nem Chand and Bros.	
2	Theory of Vibration with Application	William T. Thomson, Marie Dillon Dahleh, Chandramouli	Pearson Education	5th edition
3	Mechanical Vibrations	V. P. Singh	Dhanpat Rai & Company	
4	Mechanical Vibrations and Noise engineering	Amberkar A.G.	PHI	

E- Learning

• VTU, E- learning

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VI
Professional Elective- 1

COMPOSITE MATERIALS TECHNOLOGY

Course Code	**18ME645**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To know the behaviour of constituents in the composite materials
- To Enlighten the students in different types of reinforcement
- To Enlighten the students in different types of matrices
- To develop the student's skills in understanding the different manufacturing methods available for composite material.
- To understand the various characterization techniques
- To illuminate the knowledge and analysis skills in applying basic laws in mechanics to the composite materials.

Module-1

Introduction to Composite Materials: Definition, classification & brief history of composite materials.
Constituent of composite materials: Reinforcements, Matrix, Coupling agents, coatings & fillers.
Reinforcements: Introduction, Glass Fibers, Boron Fibers, Carbon Fibers, Organic Fibers, Ceramic Fibers, Whiskers, Other Non-oxide Reinforcements, Comparison of Fibers
Matrix Materials: Polymers, Metals and Ceramic Matrix Materials.
Interfaces: Wettability, Crystallographic nature of interface, types of bonding at the interface and optimum interfacial bond strength.

Module-2

Polymer Matrix Composites (PMC): Processing of PMC's; Processing of Thermoset Matrix Composites, Thermoplastic Matrix Composites, Sheet Moulding Compound and carbon reinforced polymer composites. Interfaces in PMC's, Structure & Properties of PMC's, applications
Metal Matrix Composites: Types of metal matrix composites, Important Metallic Matrices, Processing, Interfaces in Metal Matrix Composites, Properties & Applications.

Module-3

Ceramic Matrix Composites (CMC): Processing of CMC's; Cold Pressing & Sintering, Hot Pressing, Reaction Bonding Processes, Infiltration, Directed Oxidation, In Situ Chemical Reaction Technique, Sol-Gel, Polymer Infiltration & Pyrolysis, Electrophoretic Deposition, Self-Propagating High Temperature Synthesis. Interfaces, properties and applications of CMC's.
Carbon Fiber/Carbon Matrix Composites: Processing of Carbon/Carbon Composites, Oxidation protection of Carbon/Carbon Composites, Properties of Carbon/Carbon Composites, and application of Carbon/Carbon Composites.
Multi-filamentary Superconducting Composites: The Problem of Flux Pinning, Types of Super Conductor, Processing & structure of Multi filamentary superconducting composites. Applications of multi-filamentary superconducting composites**.**

Module-4

Nonconventional Composites: Introduction, **Nanocomposites;** Polymer clay nanocomposites, self healing composites, self-reinforced composites. Biocomposites, **Laminates;** Ceramic Laminates, Hybrid Composites. **Performance/Characterization of Composites: Static Mechanical Properties;** Tensile Properties, Compressive Properties, Flexural Properties, In-Plane Shear Properties, Interlaminar Shear Strength.
Fatigue Properties; Tension–Tension Fatigue, Flexural Fatigue. **Impact Properties;** Charpy, Izod, and Drop-Weight Impact Test.

Module-5

Micromechanics of Composites: Density, Mechanical Properties**;** Prediction of Elastic Constants, Micromechanical Approaches, Halpin-Tsai Equations, Transverse Stresses, Thermal properties. Numerical Problems.

Macromechanics of Composites: Introduction, Elastic constants of an isotropic material, elastic constants of a lamina, relationship between engineering constants and reduced stiffnesses and compliances.

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

CO1: Use different types of manufacturing processes in the preparation of composite materials

CO2: Analyze the problems on macro mechanical 88ehavior of composites

CO3: Analyze the problems on micromechanical 88ehavior of Composites

CO4: Determine stresses and strains relation in composites materials.

CO5: Understand and effective use of properties in design of composite structures

CO6: Perform literature search on a selected advanced material topic.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Composite Material Science and Engineering	Krishan K. Chawla	Springer	Third Edition First Indian Reprint 2015
2	Fibre-Reinforced Composites, Materials, Manufacturing, and Design	P.K. Mallick	CRC Press, Taylor & Francis Group	Third Edition
3	Mechanics of Composite Materials & Structures	MadhijitMukhopadhay	Universities Press	2004
Reference Books				
1	Mechanics of Composite materials	Autar K. Kaw	CRC Taylor & Francis	2nd Ed, 2005
2	Stress analysis of fiber Reinforced Composites Materials	Michael W, Hyer	Mc-Graw Hill International	2009
3	Mechanics of Composite Materials	.Robert M. Jones	Taylor & Francis	1999

E- Learning

• VTU, E- learning

B. E. MECHANICAL ENGINEERING

Choice Based Credit System (CBCS) and Outcome Based Education (OBE)

SEMESTER – VI

Professional Elective- 1

ENTREPRENEURSHIP DEVELOPMENT

Course Code	**18ME646**	**CIE Marks**	**40**
Teaching Hours/Week (L:T:P)	**3:0:0**	**SEE Marks**	**60**
Credits	**03**	**Exam Hours**	**03**

Course Learning Objectives:

- To enable the students to understand the concept of Entrepreneur and Entrepreneurship and relevant roles
- To enable the students to learn creativity and entrepreneurial plan including Project Feasibility and Project Appraisal
- To enable the students to understand Corporate entrepreneurship and issues related to Corporate entrepreneurship
- To enable the students to understand Family and Non Family Entrepreneur & Women entrepreneurs and women entrepreneurs in India
- To enable the students to understand International Entrepreneurship Opportunities and Case studies on Indian Start ups

Module-1

Entrepreneurship: Definition of Entrepreneur, Internal and External Factors, Functions of an Entrepreneur, Entrepreneurial motivation and Barriers, Classification of Entrepreneurship, Theory of Entrepreneurship, Concept of Entrepreneurship, Development of entrepreneurship; Concept of entrepreneur ,Manager and Intraprenuer(differences in their roles, responsibilities and Career Opportunities)

Module-2

Creativity and Entrepreneurial Plan: The business plan as an entrepreneurial tool, Contents of a business plan, Idea Generation, Screening and Project Identification, Creative Performance, Feasibility Analysis: Economic, Marketing, Financial and Technical; Project Planning: Evaluation, Monitoring and Control segmentation. Creative Problem Solving: Heuristics, Brainstorming, Synectics, Value Analysis, Innovation. Project Feasibility and Project Appraisal.

Module-3

Corporate entrepreneurship: Introduction, Flavors of corporate entrepreneurship, Corporate venturing, Intrapreneurship, organizational transformation, Industry rule bending, Need for corporate entrepreneurship, domain of corporate entrepreneurship, conditions favorable for Corporate entrepreneurship, benefits of Corporate entrepreneurship, issues related to Corporate entrepreneurship.

Module-4

Family and Non Family Entrepreneur & Women entrepreneurs: Role of Professionals, Professionalism vs family entrepreneurs, Role of Woman entrepreneur, , Factors influencing women entrepreneur, Challenges for women entrepreneurs, Growth and development of women entrepreneurs in India

Module-5

International Entrepreneurship Opportunities: The nature of international entrepreneurship, Importance of international business to the firm, International versus domestics' entrepreneurship, Stages of economic development. Institutional support for new ventures: Supporting Organizations; Incentives and facilities; Financial Institutions and Small scale Industries, Govt. Policies for SSIs. Case studies on Indian Start ups

Course outcomes:

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

1. understand the concept of Entrepreneur and Entrepreneurship and relevant roles
2. learn creativity and entrepreneurial plan including Project Feasibility and Project Appraisal
3. understand Corporate entrepreneurship and issues related to Corporate entrepreneurship
4. understand Family and Non Family Entrepreneur & Women entrepreneurs and women entrepreneurs in India
5. understand International Entrepreneurship Opportunities and Case studies on Indian Start ups

Question paper pattern:

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

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
01	Dynamics of Entrepreneurship Development	Vasant Desai	Himalaya Publication house	2011
02	Entrepreneurship , New Venture Creation	David Holt	Prentice Hall India	1991
03	Entrepreneurial Development	S.S. Khanka	S.Chand& Company Ltd. New Delhi	2013
04	Innovation and Entrepreneurship	Peter F. Drucker	Butterworth-Heinemann	2006

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
01	Entreprenuership – Theory, Process and Practice	Donald F Kuratko	Cengage Learning	9th Edition, 2014
02	"Entrepreneurship	Rajeev Roy	Oxford University Press	2nd Edition, 2011
03	"Enterprenuership theory at cross roads: paradigms and praxis	Mathew J Manimala	Dream tech,	2 Edition 2005
04	Entrepreneurship	Hisrich R D, Peters M P	Tata McGraw-Hill	8th Edition 2013.

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER –VI
OPEN ELECTIVE A

NON CONVENTIONAL ENERGY SOURCES

Course Code	**18ME651**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To introduce the concepts of solar energy, its radiation, collection, storage and application.
- To introduce the concepts and applications of Wind energy, Biomass energy, Geothermal energy and Ocean energy as alternative energy sources.
- To explore society's present needs and future energy demands.
- To examine energy sources and systems, including fossil fuels and nuclear energy, and then focus on alternate, renewable energy sources such as solar, biomass (conversions), wind power, geothermal, etc.
- To get exposed to energy conservation methods.

Module-1

Introduction: Energy source, India's production and reserves of commercial energy sources, need for non-conventional energy sources, energy alternatives, solar, thermal, photovoltaic. Water power, wind biomass, ocean temperature difference, tidal and waves, geothermal, tar sands and oil shale, nuclear (Brief descriptions); advantages and disadvantages, comparison (Qualitative and Quantitative).

Solar Radiation: Extra-Terrestrial radiation, spectral distribution of extra terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data.

Measurement of Solar Radiation: Pyrometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working.

Module-2

Solar Radiation Geometry: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle expression for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time. Apparent motion of sum, day length, numerical examples.

Radiation Flux on a Tilted Surface: Beam, diffuse and reflected radiation, expression for flux on a tilted surface (no derivations) numerical examples.

Solar Thermal Conversion: Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters concentrating collectors (cylindrical, parabolic, paraboloid) (Quantitative analysis); sensible heat storage, latent heat storage, application of solar energy water heating. Space heating and cooling, active and passive systems, power generation, refrigeration. Distillation (Qualitative analysis) solar pond, principle of

Module-3

Performance Analysis of Liquid Flat Plate Collectors: General description, collector geometry, selective surface (qualitative discussion) basic energy-balance equation, stagnation temperature, transmissivity of the cover system, transmissivity – absorptivity product, numerical examples. The overall loss coefficient, correlation for the top loss coefficient, bottom and side loss coefficient, problems (all correlations to be provided). Temperature distribution between the collector tubes, collector heat removal factor, collector efficiency factor and collector flow factor, mean plate temperature, instantaneous efficiency (all expressions to be provided). Effect of various parameters on the collector performance; collector orientation, selective surface, fluid inlet temperature, number covers, dust.

Photovoltaic Conversion: Description, principle of working and characteristics, application.

Module-4

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

Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations.

Ocean Thermal Energy Conversion: Principle of working, Rankine cycle, OTEC power stations in the world, problems associated with OTEC.

Module-5

Geothermal Energy Conversion: Principle of working, types of geothermal station with schematic diagram, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy.

Energy from Bio Mass: Photosynthesis, photosynthetic oxygen production, energy plantation, bio gas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of bio-gas, problems involved with bio-gas production, application of bio-gas, application of bio-gas in engines, advantages.

Hydrogen Energy: Properties of Hydrogen with respected to its utilization as a renewable form of energy, sources of hydrogen, production of hydrogen, electrolysis of water, thermal decomposition of water, thermo chemical production bio-chemical production.

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

CO1: Describe the environmental aspects of non-conventional energy resources. In Comparison with various conventional energy systems, their prospects and limitations.

CO2: Know the need of renewable energy resources, historical and latest developments.

CO3: Describe the use of solar energy and the various components used in the energy production with respect to applications like-heating, cooling, desalination, power generation, drying, cooking etc.

CO4: Appreciate the need of Wind Energy and the various components used in energy generation and know the classifications.

CO5: Understand the concept of Biomass energy resources and their classification, types of biogas Plants-applications

CO6: Compare Solar, Wind and bio energy systems, their prospects, Advantages and limitations.

CO7: Acquire the knowledge of fuel cells, wave power, tidal power and geothermal principles and applications.

Question paper pattern:

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

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Non-Convention Energy Resources	B H Khan	McGraw Hill Education (India) Pvt. Ltd.	3rd Edition
2	Solar energy	Subhas P Sukhatme	Tata McGraw Hill	2nd Edition, 1996.
3	Non-Conventional Energy Sources	G.D Rai	Khanna Publishers	2003
Reference Books				
1	Renewable Energy Sources and Conversion Technology	N.K.Bansal, Manfred Kleeman&MechaelMeliss	Tata McGraw Hill.	2004
2	Renewable Energy Technologies	Ramesh R & Kumar K U	Narosa Publishing House New Delhi	
3	Conventional Energy Systems	K M, Non	Wheeler Publishing Co. Ltd., New Delhi	2003

4	Non-Conventional Energy	Ashok V Desai	Wiley Eastern Ltd, New Delhi	2003

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER –VI
OPEN ELECTIVE A

WORLD CLASS MANUFACTURING

Course Code	**18ME652**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the concept of world class manufacturing, dynamics of material flow, and Lean manufacturing.
- To familiarize the students with the concepts of Business excellence and competitiveness.
- To apprise the students with the need to meet the current and future business challenges.
- To prepare the students to understand the current global manufacturing scenario.

Module-1

Historical Perspective World class Excellent organizations – Models for manufacturing excellence: Schonberger, Halls, Gunn and Maskell models, Business Excellence.

Module-2

Benchmark, Bottlenecks and Best Practices, Concepts of benchmarking, Bottleneck and best practices, Best performers – Gaining competitive edge through world class manufacturing – Value added manufacturing – Value Stream mapping – Eliminating waste –Toyota Production System –Example.

Module-3

System and Tools for World Class Manufacturing. Improving Product & Process Design – Lean Production – SQC, FMS, Rapid Prototyping, Poka Yoke, 5-S,3 M, JIT, Product Mix , Optimizing , Procurement & stores practices , Total Productive maintenance, Visual Control.

Module-4

Human Resource Management in WCM: Adding value to the organization– Organizational learning – techniques of removing Root cause of problems–People as problem solvers–New organizational structures. Associates–Facilitators– Teamsmanship–Motivation and reward in the age of continuous improvement.

Module-5

Typical Characteristics of WCM Companies Performance indicators like POP, TOPP and AMBITE systems– what is world class Performance –Six Sigma philosophy.
Indian Scenario on world class manufacturing –Task Ahead. Green Manufacturing, Clean manufacturing, Agile manufacturing.

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

CO1: Understand recent trends in manufacturing.
CO2: Demonstrate the relevance and basics of World Class Manufacturing.
CO3: Understand customization of product for manufacturing.
CO4: Understand the implementation of new technologies.
CO5: Compare the existing industries with WCM industries.

Question paper pattern:

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

Updated on 16.04.2020/28092020

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	World Class Manufacturing- Strategic Perspective	Sahay B.S., Saxena KBC. and Ashish Kumar	Mac Milan Publications	New Delhi
2	Just In Time Manufacturing	Korgaonkar M.G	MacMilan Publications	
Reference Books				
1	Production and Operational Management	Adam and Ebert	Prentice Hall learning Pvt. Ltd.	5th Edition
2	The Toyota Way – 14 Management Principles	Jeffrey K.Liker	Mc-Graw Hill	2003
3	Operations Management for Competitive Advantage	Chase Richard B., Jacob Robert	McGraw Hill Publications	11th Edition 2005
4	Making Common Sense Common Practice	Moore Ron	Butterworth-Heinemann	2002
5	World Class Manufacturing- The Lesson of Simplicity	Schonberger R. J	Free Press	1986

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER –VI
OPEN ELECTIVE A

SUPPLY CHAIN MANAGEMENT

Course Code	**18ME653**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To acquaint with key drivers of supply chain performance and their inter-relationships with strategy.
- To impart analytical and problem-solving skills necessary to develop solutions for a variety of supply chain management & design problems.
- To study the complexity of inter-firm and intra-firm coordination in implementing programs such as e-collaboration, quick response, jointly managed inventories and strategic alliances.

Module-1

Introduction: Supply Chain – Fundamentals –Evolution- Role in Economy - Importance - Decision Phases – Supplier Manufacturer-Customer chain. - Enablers/ Drivers of Supply Chain Performance. Supply chain strategy - Supply Chain Performance Measures.

Module-2

Strategic Sourcing Outsourcing – Make Vs buy - Identifying core processes - Market Vs Hierarchy - Make Vs buy continuum -Sourcing strategy - Supplier Selection and Contract Negotiation. Creating a world class supply base- Supplier Development - World Wide Sourcing.

Module-3

Warehouse Management Stores management-stores systems and procedures-incoming materials control-stores accounting and stock verification Obsolete, surplus and scrap-value analysis-material handling-transportation and traffic management -operational efficiency-productivity-cost effectiveness-performance measurement.

Supply Chain Network Distribution Network Design – Role - Factors Influencing Options, Value Addition – Distribution Strategies - Models for Facility Location and Capacity allocation. Distribution Center Location Models.

Module-4

Supply Chain Network optimization models. Impact of uncertainty on Network Design - Network Design decisions using Decision trees. Planning Demand, -multiple item -multiple location inventory management. Pricing and Revenue Management.

Module-5

Current Trends: Supply Chain Integration - Building partnership and trust in Supply chain Value of Information: Bullwhip Effect - Effective forecasting - Coordinating the supply chain. Supply Chain restructuring, Supply Chain Mapping - Supply Chain process restructuring, Postpone the point of differentiation – IT in Supply Chain - Agile Supply Chains -Reverse Supply chain. Future of IT in supply chain- E-Business in supply chain.

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

CO1: Understand the framework and scope of supply chain management.

CO2: Build and manage a competitive supply chain using strategies, models, techniques and information technology.

CO3: Plan the demand, inventory and supply and optimize supply chain network.

CO4: Understand the emerging trends and impact of IT on Supply chain.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.

- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Supply Chain Management– Text and Cases	Janat Shah	Pearson Education	2009
2	Supply Chain Management- Strategy Planning and Operation	Sunil Chopra and Peter Meindl	PHI Learning / Pearson Education	2007
Reference Books				
1	Business Logistics and Supply Chain Management	Ballou Ronald H	Pearson Education	5th Edition, 2007
2	Designing and Managing the Supply Chain: Concepts, Strategies, and Cases	David Simchi-Levi, Philip Kaminsky, Edith Simchi-Levi	Tata McGraw-Hill	2005
3	Supply Chain Management- Concept and Cases	Altekar Rahul V	PHI	2005
4	Modeling the Supply Chain	Shapiro Jeremy F	Thomson Learning	Second Reprint , 2002
5	Principles of Supply Chain Management- A Balanced Approach	Joel D. Wisner, G. Keong Leong, Keah-Choon Tan	South-Western, Cengage Learning	2008

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER –VI
OPEN ELECTIVE A

ADVANCED MATERIALS TECHNOLOGY

Course Code	**18ME654**	CIE Marks	40
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To impart knowledge on material selection methods and basics of advanced engineering materials.
- To introduce the basics of smart materials, composite materials, ceramics and glasses and modern metallic materials and their applications in engineering.

Module-1

Classification and Selection of Materials: Classification of materials, properties required in Engineering materials, Selection of Materials; Motivation for selection, cost basis and service requirements - Selection for mechanical properties, strength, toughness, fatigue and creep - Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing - Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications.

Module-2

Composite Materials: Fiber reinforced, laminated and dispersed materials with metallic matrix of aluminium, copper and Titanium alloys and with non-metallic matrix of unsaturated polyesters and epoxy resins. Development, Important properties and applications of these materials.

Module-3

Ceramics and Glasses - Bio-ceramics: Nearly inert ceramics, bio-reactive glasses and glass ceramics, porous ceramics; Calcium phosphate ceramics: grafts, coatings Physico-chemical surface modification of materials used in medicine.

Low & High Temperature Materials: Properties required for low temperature applications, Materials available for low temperature applications, Requirements of materials for high temperature applications, Materials available for high temperature applications, Applications of low and high temperature materials.

Module-4

Modern Metallic Materials: Dual Steels, Micro alloyed, High Strength Low alloy (HSLA) Steel, Transformation induced plasticity (TRIP) Steel, Maraging Steel, Inter metallics, Ni and Ti Aluminides.

Non-metallic Materials: Polymeric materials and their molecular structures, Production Techniques for Fibers, Foams, Adhesives and Coatings, structure, Properties and Applications of Engineering Polymers.

Module-5

Smart Materials: Shape Memory Alloys, Varistors and Intelligent materials for bio-medical applications.

Nanomaterials: Definition, Types of nanomaterials including carbon nanotubes and nanocomposites, Physical and mechanical properties, Applications of nanomaterials.

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

CO1: Explain the concepts and principles of advanced materials and manufacturing processes.

CO2: Understand the applications of all kinds of Industrial materials.

CO3: Apply the material selection concepts to select a material for a given application.

CO4: Define Nanotechnology, Describe nano material characterization.

CO5: Understand the behaviour and applications of smart materials, ceramics, glasses and non-metallic materials.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Reference Books				
1	Engineering Material Technology	James A. Jacobs & Thomas F. Kilduff	Prentice Hall	
2	Materials Science and Engineering	WD. Callister Jr.	Wiley India Pvt. Ltd	2010
3	Engineering Design: A Materials and Processing Approach	G.E. Dieter	McGraw Hill	1991
4	Materials Selection in Mechanical Design	M.F. Ashby	Pergamon Press	1992
5	Introduction to Engineering Materials & Manufacturing Processes	NIIT	Prentice Hall of India	
6	Engineering Materials Properties and Selection	Kenneth G. Budinski	Prentice Hall of India	
7	Selection of Engineering Materials	Gladius Lewis	Prentice-Hall, New Jersey	

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

COMPUTER AIDED MODELLING AND ANALYSIS LAB

Course Code	**18MEL66**	CIE Marks	40
Teaching Hours /Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To acquire basic understanding of Modeling and Analysis software
- To understand the concepts of different kinds of loading on bars, trusses and beams, and analyze the results pertaining to various parameters like stresses and deformations.
- To lean to apply the basic principles to carry out dynamic analysis to know the natural frequencies of different kind of beams.

Sl. No.	Experiments
	PART A
1	**Study of a FEA package and modeling and stress analysis of:** a. Bars of constant cross section area, tapered cross section area and stepped bar b. Trusses – (**Minimum 2 exercises of different types)** c. Beams – Simply supported, cantilever, beams with point load , UDL, beams with varying load etc. **(Minimum 6 exercises)** d. Stress analysis of a rectangular plate with a circular hole.
	PART B
2	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions **(Minimum 4 exercises of different types)**
3	Dynamic Analysis to find: a) Natural frequency of beam with fixed – fixed end condition b) Response of beam with fixed – fixed end conditions subjected to forcing function c) Response of Bar subjected to forcing functions
	PART C(only for demo)
4	a. Demonstrate the use of graphics standards (IGES, STEP etc) to import the model from modeler to solver. b. Demonstrate one example of contact analysis to learn the procedure to carry out contact analysis. c. Demonstrate at least two different types of example to model and analyze bars or plates made from composite material.

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

CO1: Use the modern tools to formulate the problem, create geometry, descritize, apply boundary conditions to solve problems of bars, truss, beams, and plate to find stresses with different-loading conditions.

CO2: Demonstrate the ability to obtain deflection of beams subjected to point, uniformly distributed and varying loads and use the available results to draw shear force and bending moment diagrams.

CO3: Analyze and solve 1D and 2D heat transfer conduction and convection problems with different boundary conditions.

CO4: Carry out dynamic analysis and finding natural frequencies of beams, plates, and bars for various boundary conditions and also carry out dynamic analysis with forcing functions.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.

Scheme of Examination:

One Question from Part A - 40 Marks
One Question from Part B - 40 Marks
Viva-Voce - 20 Marks

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

HEAT TRANSFER LAB

Course Code	**18MEL67**	CIE Marks	40
Teaching Hours/Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- The primary objective of this course is to provide the fundamental knowledge necessary to understand the behavior of thermal systems.
- This course provides a detailed experimental analysis, including the application and heat transfer through solids, fluids, and vacuum.
- Convection, conduction, and radiation heat transfer in one and two dimensional steady and unsteady systems are examined.

Sl. No.	Experiments
	PART A
1	Determination of Thermal Conductivity of a Metal Rod.
2	Determination of Overall Heat Transfer Coefficient of a Composite wall.
3	Determination of Effectiveness on a Metallic fin.
4	Determination of Heat Transfer Coefficient in free Convection
5	Determination of Heat Transfer Coefficient in a Forced Convention
6	Determination of Emissivity of a Surface.
	PART B
7	Determination of Stefan Boltzmann Constant.
8	Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers.
9	Experiments on Boiling of Liquid and Condensation of Vapour.
10	Performance Test on a Vapour Compression Refrigeration.
11	Performance Test on a Vapour Compression Air – Conditioner.
12	Experiment on Transient Conduction Heat Transfer.
	PART C (OPTIONAL)
13	Analysis of steady and transient heat conduction, temperature distribution of plane wall and cylinder using Numerical approach (ANSYS/CFD package).
14	Determination of temperature distribution along a rectangular and circular fin subjected to heat loss through convection using Numerical approach (ANSYS/CFD package).

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

CO1: Determine the thermal conductivity of a metal rod and overall heat transfer coefficient of composite slabs.

CO2: Determine convective heat transfer coefficient for free and forced convection and correlate with theoretical values.

CO3: Evaluate temperature distribution characteristics of steady and transient heat conduction through solid cylinder experimentally.

CO4: Determine surface emissivity of a test plate and Stefan Boltzmann constant

CO5: Estimate performance of a refrigerator and effectiveness of a fin and Double pipe heat exchanger

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made

Scheme of Examination:

One Question from Part A - 40 Marks

One Question from Part B - 40 Marks

Viva-Voce - 20 Marks

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VII

CONTROL ENGINEERING

Course Code	**18ME71**	CIE Marks	40
Teaching Hours / Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To develop comprehensive knowledge and understanding of modern control theory, industrial automation, and systems analysis.
- To model mechanical, hydraulic, pneumatic and electrical systems.
- To represent system elements by blocks and its reduction techniques.
- To understand transient and steady state response analysis of a system.
- To carry out frequency response analysis using polar plot, Bode plot.
- To analyse a system using root locus plots.
- To study different system compensators and characteristics of linear systems.

Module-1

Introduction: Components of a control system, Open loop and closed loop systems.
Types of controllers: Proportional, Integral, Differential, Proportional-Integral, and Proportional- Integral-Differential controllers.
Modelling of Physical Systems: Mathematical Models of Mechanical, Electrical, Thermal, Hydraulic Systems.

Module-2

Time domain performance of control systems: Typical test signal, Unit step response and time domain specifications of first order, second order system. Steady state error, error constants.

Module-3

Block diagram algebra, Reduction of block diagram, Signal flow graphs, Gain formula for signal flow graphs, State diagram from differential equations.

Module-4

Stability of linear control systems: Routh's criterion, Root locus, Determination of phase margin and gain margin using root locus.

Module-5

Stability analysis using Polar plot, Nyquist plot, Bode plot, Determination of phase margin and gain margin using Bode plot.

Assignment:
1.Study of On-Off Controller for Flow/ Temperature.
2. Study of Control Modes like P, PD, PI, PID for Pressure / Temperature / Flow.
3. Assignment on Root Locus, Bode Plots and Polar Plots.
4. Use of Software 'MATLAB' on the above topics.

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

CO1: Identify the type of control and control actions.
CO2: Develop the mathematical model of the physical systems.
CO3: Estimate the response and error in response of first and second order systems subjected standard input signals.
CO4: Represent the complex physical system using block diagram and signal flow graph and obtain transfer function.
CO5: Analyse a linear feedback control system for stability using Hurwitz criterion, Routh's criterion and root Locus technique in complex domain.

CO6: Analyse the stability of linear feedback control systems in frequency domain using polar plots, Nyquist and Bode plots.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Automatic Control Systems	Farid G., Kuo B. C	McGraw Hill Education	10th Edition,2018
2	Control systems	Manik D. N	Cengage	2017
Reference Books				
1	Modern control Engineering	K. Ogeta	Pearson	5th Edition, 2010
2	Control Systems Engineering	Norman S Nice		Fourth Edition, 2007
3	Modern control Systems	Richard C Dorf	Pearson	2017
4	Control Systems Engineering	IjNagrath, M Gopal	New Age International (P) Ltd	2018
5	Control Systems Engineering	S Palani	Tata McGraw Hill Publishing Co Ltd	ISBN-13 978007067193

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

COMPUTER AIDED DESIGN AND MANUFACTURING

Course Code	**18ME72**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To impart knowledge of CIM and Automation and different concepts of automation by developing mathematical models.
- To make students to understand the Computer Applications in Design and Manufacturing [CAD / CAM) leading to Computer integrated systems. Enable them to perform various transformations of entities on display devices.
- To expose students to automated flow lines, assembly lines, Line Balancing Techniques, and Flexible Manufacturing Systems.
- To expose students to computer aided process planning, material requirement planning, capacity planning etc.
- To expose the students to CNC Machine Tools, CNC part programming, and industrial robots.
- To introduce the students to concepts of Additive Manufacturing, Internet of Things, and Industry 4.0 leading to Smart Factory.

Module-1

Introduction to CIM and Automation: Automation in Production Systems, automated manufacturing systems- types of automation, reasons for automating, Computer Integrated Manufacturing, computerized elements of a CIM system, CAD/CAM and CIM. Mathematical models and matrices: production rate, production capacity, utilization and availability, manufacturing lead time, work-in- process, numerical problems.

Automated Production Lines and Assembly Systems: Fundamentals, system configurations, applications, automated flow lines, buffer storage, control of production line, analysis of transfer lines, analysis of flow lines without storage, partial automation, analysis of automated flow lines with storage buffer, fundamentals of automated assembly systems, numericals.

Module-2

CAD and Computer Graphics Software: The design process, applications of computers in design**,** software configuration, functions of graphics package, constructing the geometry.

Transformations: 2D transformations, translation, rotation and scaling, homogeneous transformation matrix, concatenation, numerical problems on transformations.

Computerized Manufacture Planning and Control System: Computer Aided Process Planning, Retrieval and Generative Systems, benefits of CAPP, Production Planning and Control Systems, typical activities of PPC System, computer integrated production management system, Material Requirement Planning, inputs to MRP system, working of MRP, outputs and benefits, Capacity Planning, Computer Aided Quality Control, Shop floor control

Module-3

Flexible Manufacturing Systems: Fundamentals of Group Technology and Flexible Manufacturing Systems, types of FMS, FMS components, Material handling and storage system, applications, benefits, computer control systems, FMS planning and design issues, Automated Storage and Retrieval Systems, AS/RS and Automatic parts identification systems and data capture.

Line Balancing: Line balancing algorithms, methods of line balancing, numerical problems on largest candidate rule, Kilbridge and Wester method, and Ranked Positional Weights method, Mixed Model line

balancing, computerized line balancing methods.

Module-4

Computer Numerical Control: Introduction, components of CNC, CNC programming, manual part programming, G Codes, M Codes, programming of simple components in turning, drilling and milling systems, programming with canned cycles. Cutter radius compensations.

Robot Technology: Robot anatomy, joints and links, common robot configurations, robot control systems, accuracy and repeatability, end effectors, sensors in robotics. Robot programming methods: on-line and off-line methods. Robot industrial applications: material handling, processing and assembly and inspection.

Module-5

Additive Manufacturing Systems: Basic principles of additive manufacturing, slicing CAD models for AM, advantages and limitations of AM technologies, Additive manufacturing processes: Photo polymerization, material jetting, binder jetting, material extrusion, Powder bed sintering techniques, sheet lamination, direct energy deposition techniques, applications of AM.

Future of Automated Factory: Industry 4.0, functions, applications and benefits. Components of Industry 4.0, Internet of Things (IOT), IOT applications in manufacturing, Big-Data and Cloud Computing for IOT, IOT for smart manufacturing, influence of IOT on predictive maintenance, industrial automation, supply chain optimization, supply-chain & logistics, cyber-physical manufacturing systems.

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

CO1: Define Automation, CIM, CAD, CAM and explain the differences between these concepts. Solve simple problems of transformations of entities on computer screen

CO2: Explain the basics of automated manufacturing industries through mathematical models and analyze different types of automated flow lines.

CO3: Analyse the automated flow linestoreduce time and enhance productivity.

CO4: Explain the use of different computer applications in manufacturing, and able to prepare part programs forsimple jobs on CNC machine tools and robot programming.

CO5: Visualize and appreciate the modern trends in Manufacturing like additive manufacturing, Industry 4.0 and applications of Internet of Things leading to Smart Manufacturing.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Automation, Production Systems and Computer-Integrated Manufacturing	Mikell P Groover	Pearson Learning.	4th Edition,2015
2	CAD / CAM Principles and Applications	P N Rao	Tata McGraw-Hill	3rd Edition, 2015
3	CAD/CAM/CIM	Dr. P. Radhakrishnan	New Age International Publishers, New Delhi.	3rd edition
Reference Books				
1	"CAD/CAM"	Ibrahim Zeid	Tata McGraw Hill.	
2	Principles of Computer Integrated Manufacturing	S.Kant Vajpayee	, Prentice Hall of India, New Delhi.	1999

3	Work Systems And The Methods, Measurement And Management of Work	Groover M. P.,Pearson	Prentice Hall	Upper Saddle River, NJ, 2007.
4	Computer Automation in Manufacturing	Boucher, T. O., Chapman & Hall	London, UK,	1996.
5	Introduction to Robotics: Mechanics And Control	Craig, J. J.	Addison-Wesley Publishing Company	2nd Ed 1989.
6	Internet of Things (IoT): Digitize or Die: Transform your organization. Embrace the digital evolution. Rise above the competition	Nicolas Windpassinger	Amazon.	
7	Internet of Things: A Hands-on Approach"	ArshdeepBahga and Vijay Madisetti	Universities Press	
8	Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing,	Ian Gibson, David W. Rosen, Brent Stucker		2nd Ed. (2015)
9	Understanding Additive Manufacturing	Andreas Gebhardt, Hanser Publishers		2011
10	Understanding Additive Manufacturing",	Andreas Gebhardt,	Hanser Publishers,	2011

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VII
Professional Elective 2

DESIGN FOR MANUFACTURE

Course Code	**18ME731**	CIE Marks	40
Teaching Hours / Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To educate students on factors to be considered in designing parts and components with focus on manufacturability.
- To expose the students to dimensional tolerances, geometric tolerances and true position tolerance techniques in manufacture.
- To impart the knowledge on design considerations for designing components produced using various machining operations like turning, drilling, milling, grinding etc.
- To educate the students on design rules and recommendations for processes like casting, welding, forgings powder metallurgy and injection moulding.

Module-1

Introduction: Definition, need for DFM, DFM approach for cost reduction, general design guide lines of DFM, advantages and disadvantages, application of DFM in industries, Design for Quality Manufacturability, DFQM approach, designing for economical production. Design for Excellence (DFX).

Engineering Tolerancing: Basics of dimensional tolerancing, Redundancy, tolerance allocation, Review of relationship between attainable tolerance grades and different machining processes. Geometrical tolerances. Process capability, mean, variance, skewness, kurtosis, process capability indices- C_p, and C_{pk}. Cumulative effect of tolerance- Sure fit law and truncated normal law, problems.

Module-2

True positional theory: Comparison between coordinate and true position method of feature location. True position tolerance- virtual size concept, concepts of datum and changing datum, floating and fixed fasteners, projected tolerance zone and functional gages. Concept of Zero true position tolerance. Simple problems on true position tolerancing.

Selective Assembly: Interchangeable part manufacture and selective assembly. Deciding the number of groups -model-1: group tolerance of mating parts equal, model- 2: total and group tolerances of shaft equal. Control of axial play- introducing secondary machining operations, and laminated shims; examples.

Module-3

Datum Features: Functional datum, datum for manufacturing, changing the datum; examples.

Component Design: Design features to facilitate machining: drills, milling cutters, keyways, Doweling procedures, counter sunk screws, Reduction of machined area, simplification by separation, simplification by amalgamation, Design for machinability, Design for economy, Design for clampability, Design for accessibility. Designing for heat treatment, roller burnishing, and economical de-burring.

Module-4

Design of components with casting considerations: Pattern, mould, and parting line. Cored holes and machined holes. Identifying the possible and probable parting lines. Castings requiring special sand cores. Designing to obviate sand cores.

Welding considerations: Advantages of weldments over other design concepts, design requirements and rules, redesign of components for welding; case studies.

Module-5

Forging considerations -requirements and rules-redesign of components for forging and case studies.
Design of components for powder metallurgy- requirements and rules-case studies.
Design of components for injection moulding- requirements and rules-case studies.

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

CO1: Select proper materials and manufacturing processes for designing products/components by applying the relevant principles for ease and economic production.
CO2: Identify faulty design factors leading to increased costs in producing mechanical components.
CO3: Apply appropriate design tolerances – dimensional, geometric and true position tolerances for the production processes of mechanical components.
CO4: Apply the concepts related to reducing machined areas, simplification by amalgamation and separation, clampability, accessibility etc., in the design of mechanical components.
CO5: Analyse the design of castings, weldments, forgings, powder metallurgy components and suggest design modifications to reduce the cost.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Designing for Manufacture	Peck H	Pitman Publications	1983
2	Engineering Design: A Materials and processing Approach	Dieter, G.E.	McGraw Hill Co.Ltd	2000
3	Handbook of Products Design for Manufacturing: A Practical Guide to Low-cost Production	Bralla, James G.	McGraw Hill, New York	1986
Reference Books				
1	Engineering Design	Eggert, R.J	Pearson Education, Inc., New Jersey	2005
2	Engineering Design	Matousek , R	Blackie and Son Limited, Glasgow	1967
3	Engineering Design for Manufacture	Kalandar Saheb, S.D and Prabhakar, O.	ISPE	1999
4	Design for Economical Production	Trucks, H.E.	Mich., Dearborn, SME	2nd ed.,1987
5	Processes and Materials of Manufacture	Linberg, Roy A.	Allyn and Bacon, Boston, U.S.A.	4th ed., 1990

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VII
Professional Elective 2

AUTOMATION & ROBOTICS

Course Code	**18ME732**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:2:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To identify potential areas for automation and justify need for automation.
- To select suitable major control components required to automate a process or an activity
- To study the various parts of robots and fields of robotics.
- To study the various kinematics and inverse kinematics of robots.
- To study the control of robots for some specific applications.

Module-1:

Introduction to automation:
Basic elements of an automated system, advanced automation functions, levels of automation, process industries versus discrete manufacturing industries, continuous versus discrete control, computer process control. Hardware components for automation and process control, sensors, actuators, analog to digital converters, digital to analog converters, input/output devices for discrete data

Module-2:

Automated production lines:
Fundamentals of automated production lines, application of automated production lines, analysis of transfer lines, automated assembly systems, fundamentals of automated assembly systems, quantitative analysis of assembly systems, automatic identification methods, barcode technology, radio frequency identification, other AIDC technologies

Module-3: Industrial Robotics

Robotic configuration, robot anatomy and related attributes, robot control systems, end effectors, sensors in robotics, industrial robot applications, robot accuracy and repeatability, different types of robots, various generations of robots, degrees of freedom – Asimov's laws of robotics, dynamic stabilization of robots.

Module-4: Spatial descriptions and transformations

Robot actuators and Feedback components: Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors, comparison. Position sensors –potentiometers, resolvers, encoders –Velocity sensors, Tactile sensors, Proximity sensors. Manipulator Kinematics: Homogeneous transformations as applicable to rotation and translation -D-H notation, Forward and inverse kinematics.

Module-5: Robot programming

Introduction, levels of robot programming, requirements of robot programming language, problems pertaining to robot programming languages, offline programming systems, central issues in OLP systems, automating subtasks in OLP systems, simple programs on robot applications.

Course Outcomes: At the end of the course, the student will be able to:
CO1: Translate and simulate a real time activity using modern tools and discuss the Benefits of automation.
CO2: Identify suitable automation hardware for the given application.
CO3: Recommend appropriate modelling and simulation tool for the given manufacturing Application.
CO4: Explain the basic principles of Robotic technology, configurations, control and Programming of Robots.
CO5: Explain the basic principles of programming and apply it for typical Pick & place, Loading & unloading and palletizing applications

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Computer Integrated Manufacturing	Mikell P. Groover	Pearson	3rd edition, 2009
2	Introduction to robotics mechanics and control	John J. Craig	Pearson	3rd edition, 2009
Reference Books				
1	Robotics for Engineers	Yoram Koren	McGraw Hill International	1st edition, 1985.
2	Industrial Robotics	Weiss, Nagel	McGraw Hill International	2nd edition, 2012
3	Robotic Engineering - An Integrated approach	Klafter, Chmielewski and Negin	PHI	1st edition, 2009
4	Computer Based Industrial Control	Krishna Kant	EEE-PHI	2nd edition,2010
5	An Introduction to Automated Process Planning System	Tiess Chiu Chang & Richard A. Wysk.		

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VII
Professional Elective 2

COMPUTATIONAL FLUID DYNAMICS

Course Code	**18ME733**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Study the governing equations of fluid dynamics
- Learn how to formulate and solve Euler's equation of motion.
- Become skilled at Representation of Functions on Computer
- Solve computational problems related to fluid flows

Module-1

Introduction to CFD and Governing Equations

Need of CFD as tool, role in R&D, continuum, material or substantial derivative or total derivative, gradient, divergence and curl operators, Linearity, Principle of Superposition. Derivation of Navier-Stokes equations in control volume (integral form) and partial differential form, Euler equations (governing inviscid equations). Mathematical classification of PDE (Hyperbolic, Parabolic, Elliptic). Method of characteristics, Introduction to Riemann Problem and Solution Techniques.

Module-2

One-dimensional Euler's equation

Conservative, Non-conservative form and primitive variable forms of Governing equations. Flux Jacobian Is there a systematic way to diagona lize '**A**'. Eigen values and Eigenvectors of Flux Jacobian. Decoupling of Governing equations, introduction of characteristic variables. Relation between the two non-conservative forms. Conditions for genuinely nonlinear characteristics of the flux Jacobian.

Introduction to Turbulence Modelling: Derivation of RANS equations and k-epsilon model.

Module-3

Representation of Functions on Computer

Need for representation of functions, Box Function, Hat Function, and Representation of sinx using hat functions: Aliasing, high frequency, low frequency. Representation error as a global error. Derivatives of hat functions, Haar functions, Machine Epsilon. Using Taylor series for representation of Derivatives.

Module-4

Finite difference method – Applied to Linear Convection equation, Laplace Equations, Convection Diffusion equations, Burgers equations, modified equations. Explicit methods and Implicit methods – as applied to applied to linear convection equation, Laplace equations, convection-diffusion equation◦ FTCS,FTFS,FTBS,CTCS ◦ Jacobi Method, Gauss-Siedel, Successive Over Relaxation Method, TDMA• Von Naumann stability (linear stability) analysis. Upwind Method in Finite Difference method.

Module-5

Finite volume method Finite volume method. Finding the flux at interface.

Central schemes - Lax-Friedrichs Method, Lax-Wendroff Method, Two-Step Lax-Wendroff Method and Mac Cormack Method

Upwind Method in Finite Volume methods - Flux Splitting Method Steger and Warming, vanLeer, Roe's Method and finding Roe's Averages.

Course Outcomes:

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

CO1: Understand mathematical characteristics of partial differential

equations.

CO2: Explain how to classify and computationally solve Euler and Navier-Stokes equations.

CO3: Make use of the concepts like accuracy, stability, consistency of numerical methods for the governing equations.

CO4: Identify and implement numerical techniques for space and time integration of partial differential equations.

CO5: Conduct numerical experiments and carry out data analysis.

CO6: Acquire basic skills on programming of numerical methods used to solve the Governing equations.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Computational Fluid Dynamics	T.j.chung	Cambridge University Press	
2	Computational fluid dynamics and heat transfer	Ghoshdastidar	Cengage learning	2017
3	Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics – Vol 1 & Vol 2	Charles Hirsch	Butterworth- Heinemann	2007
4	Numerical Heat Transfer and Fluid Flow	SuhasPatankar	Taylor and Francis Publisher	
5	Introduction Computational Fluid Dynamics -Development, Application and Analysis	Atul Sharma	Wiely Publisher	
Reference Books				
1	Computational fluid mechanics and heat transfer	Pletcher, r. H., Tannehill, j. C., Anderson, d.	Crc press, ISBN 9781591690375	3rd ed, 2011
2	Fundamentals of engineering numerical analysis	Moin, p	Cambridge university press, , ISBN 9780521805261	2nd ed, 2010
3	Numerical methods for engineering application	Ferziger, j. H	Wiley	2nd ed, 1998
4	Computational methods for fluid dynamics	Ferziger, j. H., Peric, m	Springer	3rd ed
5	Numerical methods for conservation laws	eth Zurich, birkhauser		pp-199
6	Practical Introduction	Eleuterio F Toro	Springer	

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VII
Professional Elective 2

TOTAL QUALITY MANAGEMENT

Course Code	**18ME734**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand various approaches to TQM
- Understand the characteristics of quality leader and his role.
- Develop feedback and suggestion systems for quality management.
- Enhance the knowledge in Tools and Techniques of quality management.

Module-1

Principles and Practice: Definition, basic approach, gurus of TQM, TQM Framework, awareness, defining quality, historical review, obstacles, benefits of TQM. Quality Management Systems: Introduction, benefits of ISO registration, ISO 9000 series of standards, ISO 9001 requirements.

Module-2

Leadership: Definition, characteristics of quality leaders, leadership concept, characteristics of effective people, ethics, the Deming philosophy, role of TQM leaders, implementation, core values, concepts and framework, strategic planning communication, decision making,

Module-3

Customer Satisfaction and Customer Involvement: Customer Satisfaction: customer and customer perception of quality, feedback, using customer complaints, service quality, translating needs into requirements, customer retention, case studies. Employee Involvement – Motivation, employee surveys, empowerment, teams, suggestion system, recognition and reward, gain sharing, performance appraisal, unions and employee involvement, case studies.

Module-4

Continuous Process Improvement: process, the Juran trilogy, improvement strategies, types of problems, the PDSA Cycle, problem-solving methods, Kaizen, reengineering, six sigma, case studies. Statistical Process Control: Pareto diagram, process flow diagram, cause and effect diagram, check sheets, histograms, statistical fundamentals, Control charts, state of control, out of control process, control charts for variables, control charts for attributes, scatter diagrams, case studies.

Module-5

Total Productive Maintenance (TPM): Definition, Types of Maintenance, Steps in introduction of TPM in an organization, Pillars of TPM – 5S, Jishu Hozen, Quality Maintenance, Planned Maintenance.
Quality by Design (QbD): Definition, Key components of QbD, Role of QbD in Pharmaceutical Industry, Benefits and Challenges of QbD.
Environmental Management Systems (EMS): Definition, Basic EMS, EMS under ISO 14001, Costs and Benefits of EMS.

Course Outcomes: At the end of the course, the student will be able to:
CO1: Explain the various approaches of TQM
CO2: Infer the customer perception of quality
CO3: Analyse customer needs and perceptions to design feedback systems.
CO4: Apply statistical tools for continuous improvement of systems
CO5: Apply the tools and technique for effective implementation of TQM.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Total Quality Management	Dale H. Besterfield	Pearson Education India,	Edition 03. ISBN: 8129702606,
2	Total Quality Management for Engineers	M. Zairi	Wood head Publishing	ISBN:1855730243
Reference Books				
1	Managing for Quality and Performance Excellence	James R. Evans and William M Lindsay	Cengage Learning.	9th edition
2	Four revolutions in management	Shoji Shiba, Alan Graham, David Walden	Oregon	1990
3	Organizational Excellence through TQM	H. Lal	New age Publications	2008
4	Engineering Optimization Methods and Applications	A Ravindran, K, M. Ragsdell	Willey India Private Limited	2nd Edition,2006
5	Introduction to Operations Research- Concepts and Cases	F.S. Hillier. G.J. Lieberman	Tata McGraw Hill	9th Edition, 2010

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VII
Professional Elective 2

OPERATIONS RESEARCH

Course Code	**18ME735**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To enable the students to understand the scientific methods of providing various departments of an organization with a quantitative basis of decision making.
- To enable the students to understand the importance of various tools and techniques in finding optimal solutions to problems involving limited resources in the form of Men, Materials and machinery.

Module-1

Introduction: Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models used in OR, Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as L.P.P. Solutions to LPP by graphical method (Two Variables).

Module-2

LPP: Simplex method, Canonical and Standard form of LP problem, slack, surplus and artificial variables, Solutions to LPP by Simplex method, Big-M Method and two-phase Simplex Method, Degeneracy in LPP. Concept of Duality, writing Dual of given LPP. Solutions to L.P.P by Dual Simplex Method.

Module-3

Transportation Problem: Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in Transportation problem by Modified Distribution (MODI) method. Unbalanced T.P. Maximization T.P. Degeneracy in transportation problems, application of transportation problem. Assignment Problem-Formulation, Solutions to assignment problems by Hungarian method, Special cases in assignment problems, unbalanced, Maximization assignment problems. Travelling Salesman Problem (TSP). Difference between assignment and T.S.P, Finding best route by Little's method. Numerical Problems.

Module-4

Network analysis: Introduction, Construction of networks, Fulkerson's rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, determining the probability of completing a project, predicting the completion time of project; Cost analysis in networks. Crashing of networks- Problems. Queuing Theory: Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendall & Lee's notation of Queuing, empirical queuing models – Numerical on M/M/1 and M/M/C Queuing models.

Module-5

Game Theory: Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point. Mixed Strategy problems. Solution of 2X2 games by Arithmetic method, Solution of 2Xn m and mX2 games by graphical method. Formulation of games. Sequencing: Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing of2 jobs on 'm' machines using graphical method.

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

CO1: Understand the meaning, definitions, scope, need, phases and techniques of operations research.

CO2: Formulate as L.P.P and derive optimal solutions to linear programming problems by graphical method, Simplex method, Big-M method and Dual Simplex method.

CO3: Formulate as Transportation and Assignment problems and derive optimum solutions for transportation,

Assignment and travelling salesman problems.

CO4: Solve problems on game theory for pure and mixed strategy under competitive environment.

CO5: Solve waiting line problems for M/M/1 and M/M/K queuing models.

CO6: Construct network diagrams and determine critical path, floats for deterministic and PERT networks including crashing of Networks

CO7: Determine minimum processing times for sequencing of n jobs-2 machines, n jobs-3 machines, n jobs-m machines and 2 jobs-n machines using Johnson's algorithm.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Operations Research	P K Gupta and D S Hira	S. Chand and Company LTD. Publications, New Delhi	2007
2	Operations Research, An Introduction	Hamdy A. Taha	PHI Private Limited	Seventh Edition, 2006
Reference Books				
1	Operations Research, Theory and Applications	J K Sharma	Trinity Press, Laxmi Publications Pvt.Ltd.	Sixth Edition, 2016
2	Operations Research	Paneerselvan	PHI	
3	Operations Research	A M Natarajan, P Balasubramani	Pearson Education,	2005
4	Introduction to Operations Research	Hillier and Lieberman	McGraw Hill	8thEd

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VII
Professional Elective 3

ADDITIVE MANUFACTURING

Course Code	**18ME741**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To know the principle methods, areas of usage, possibilities and limitations of the Additive Manufacturing technologies.
- To be familiar with the characteristics of the different materials those are used in Additive Manufacturing.
- To know the principles of polymerization and powder metallurgy process, extrusion-based system printing processes, sheet lamination processes, beam deposition processes, direct write technologies and Direct Digital Manufacturing.
- To get exposed to process selection, software issues and post processing.

Module-1

Introduction and basic principles: Need for Additive Manufacturing, Generic AM process, stereoli tho graphy or 3dprinting, rapid proto typing ,the benefits of AM, distinction between AM and CNC machining, other related technologies- reverse engineering technology.
Development of Additive Manufacturing Technology: Introduction, computers, computer-aidedde sign technology ,other associated technologies, the use of layers, classification of AM processes, metals ystems, hybrid systems, milestones in AM development.
Additive Manufacturing Process chain: Introduction, the eight steps in additive manufacture, variations from one AM machine to another ,metal systems, maintenance of equipment, materials handling issues, design for AM, and application areas.

Module-2

Photo polymerization processes: Stereolitho graphy (SL), Materials, SL resin curing process, Micro-stereoli thography, Process Benefits and Drawbacks, Applications of Photo polymerization Processes.
Powder bedfusion processes: Introduction, Selective laser Sintering (SLS), Materials, Powder fusion mechanism, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes.
Extrusion-based systems: Fused Deposition Modelling (FDM), Principles, Materials, Plotting and path control, Bio-Extrusion, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes.

Module-3

Printing Processes: evolution of printing as an additive manufacturing process, research achievements in printing deposition, technical challenges of printing, printing process modeling, material modification methods, three-dimensional printing, advantages of binder printing
Sheet Lamination Processes: Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications.
Beam Deposition Processes: introduction, general beam deposition process, description material delivery, BD systems , process parameters, typical materials and microstructure, processing–structure–properties relationships, BD benefits and drawbacks.
Direct Write Technologies: Background ,ink -basedDW,laser transfer, DW thermals pray,DW beam deposition,DW liquid-phase directde position.

Module-4

Guidelines for Process Selection: Introduction, selection methods for apart, challenges of selection, example system for preliminary selection, production planning and control.
Software issues for Additive Manufacturing: Introduction, preparation of cad models – the STL file, problems with STL files, STL file manipulation.
Post- Processing: Support material removal**,** surface texture improvements**,** preparation for use as a pattern, property enhancements using non-thermal techniques and thermal techniques**.**

Module-5

The use of multiple materials in additive manufacturing: Introduction, multiple material approaches, discrete multiple material processes, porous multiple material processes, blended multiple material processes, commercial applications using multiple materials, future directions.
AM Applications: Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application: Examples for Aerospace, defense, automobile, Bio-medical and general engineering industries.
Direct digital manufacturing: Align Technology, siemens and phonak, DDM drivers, manufacturing vs. prototyping, life- cycle costing, future of direct digital manufacturing.

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

CO1: Demonstrate the knowledge of the broad range of AM processes, devices, capabilities and materials that are available.
CO2: Demonstrate the knowledge of the broad range of AM processes, devices, capabilities and materials that are available.
CO3: Understand the various software tools, processes and techniques that enable advanced/additive manufacturing.
CO4: Apply the concepts of additive manufacturing to design and create components that satisfy product development/prototyping requirements, using advanced/additive manufacturing devices and processes.
CO6: Understand characterization techniques in additive manufacturing.
CO7: Understand the latest trends and business opportunities in additive manufacturing.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing	I. Gibson l D. W. Rosen l B. Stucker	Springer New York Heidelberg Dordrecht, London	ISBN: 978-1-4419-1119-3 e-ISBN: 978-1-4419-1120-9 DOI 10.1007/978-1-4419-1120-9
Reference Books				
1	“Rapid Prototyping: Principles & Applications	Chua Chee Kai, Leong Kah Fai	World Scientific	2003
2	Rapid Prototyping: Theory & Practice	Ali K. Kamrani,	Springer	2006

		EmandAbouel Nasr,		
3	Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling"	D.T. Pham, S.S. Dimov	Springer	2001
4	Rapid Prototyping: Principles and Applications in Manufacturing	RafiqNooran	John Wiley & Sons	2006
5	Additive Manufacturing Technology	Hari Prasad, A.V.Suresh	Cengage	2019
6	Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing	Andreas Gebhardt	Hanser Publishers	2011

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VII
Professional Elective 3

EMERGING SUSTAINABLE BUILDING COOLING TECHNOLOGIES

Course Code	**18ME742**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To provide an overview of emerging delivery systems for high performance green buildings and the basis on which their sustainability can be evaluated
- To know the concepts of calculations of heating and cooling loads and the related economics.
- To learn the importance of green fuels and its impact on environment.
- To expose the students to sustainable cooling technologies.

Module-1

Social and Environmental Issues related to conventional Refrigeration and Air conditioning: Climate Change and energy poverty implications of energy consumption and refrigerants use by conventional Vapor-Compression based RAC technologies, Global and Indian environmental, energy efficiency and green building policies, laws and rules warranting a trajectory shift in the RAC economy, Introduction to Thermal comfort as an 'ends' and cooling systems as a 'means', Socio-economic and environmental benefits of a Negawatt approach to energy conservation vs. a Megawatt approach towards power generation.

Module-2

Thermal Comfort, Climate Analysis and Psychrometry: The 'human thermal comfort' lens and its implications for cooling system design, Progressive models for addressing human thermal comfort needs, Thermodynamics of human body, Factors affecting human comfort, Introduction to the ASHRAE Std. 55, Adaptive Comfort Model and the Indian Model for Adaptive Comfort (IMAC) and its implications for mitigating climate change and energy consumption from cooling technologies, Tools for predicting thermal comfort in buildings, Principles and tools for climate analysis, Composition of Psychrometric Charts, Psychrometric processes of conventional and sustainable cooling technologies and representation on psychrometric chart, Application of psychrometry to design conventional and sustainable cooling technologies.

Indoor Air Quality and Building Cooling Load Modelling:

Addressing trade-offs between indoor air quality requirements, daylighting needs, and solar heat gain reduction in artificially cooled buildings. Factors affecting building cooling loads. Building cooling load

Module-3

Refrigeration Systems and Refrigerants:

Thermodynamics of Vapor Compression Refrigeration (VCR) and Vapor Absorption Machine (VAM) Cycles, Equipment used in commercial and residential VCR and VAM systems, Physical, Chemical, Thermodynamic and Environmental properties of Refrigerants and Refrigerant mixtures **(**zeotropic and azeotropic mixtures) used in conventional VCR system, Absorbent **–** Refrigerant combinations (Water-Ammonia and Lithium-Bromide) used in VAM systems, Physical, Chemical, Thermodynamic and Environmental properties of emerging Natural Refrigerants for VCR systems.

Module-4

Air conditioning:

Air conditioning demand scenarios for India and associated health, social justice, energy access, and environmental Implications for its peoples and communities, Potential sustainable air conditioning scenarios for India, Heat transfer and psychrometric principles of air conditioning cycles, Engineering principles of air conditioning components, Air conditioning coefficient-of-performance calculation, Energy efficient air conditioning system, Energy and greenhouse gas emissions-based performance comparison of natural

refrigerant and f-gas based air conditioners.

Module-5

Sustainable Cooling Technologies:

Radical social justice fostering, energy conservation, and climate change mitigation potential of natural cooling, Design principles of natural and sustainable cooling systems, Science and engineering design principles of a) Direct, Indirect, and Hybrid (Direct-Indirect and DX) Evaporative Cooling technology, b) Structure Cooling, c) Radiant Cooling Systems, and d) Solar VAM technology, Basic equipment sizing calculations, System performance assessment methods, Comparative energy consumption, greenhouse gas emissions and life-cycle cost case studies for residential and commercial applications of conventional and sustainable cooling technologies.

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

CO1: Empathize with sustainable cooling as a means of enhancing social justice in India and mitigating climate change through their intellectual capabilities and ethical orientation

CO2: Compute and Interpret cooling and heating loads in a building and how they could be efficiently managed by using building energy modelling software

CO3: Estimate the performance of airconditioning systems using the principles of thermodynamics, heat transfer, and psychometry

CO4: Calculate and interpret the energy, cost, and greenhouse gas emissions performance of conventional and sustainable cooling technologies.

Co6: Conduct building and sustainable cooling modelling projects on a sophisticated building energy modelling software.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Refrigeration and Airconditioning	C P Arora	Tata McGraw Hill	3rd Edition
2	Heating, Ventilating and Airconditioning	Faye C McQuiston, Jerald D. Parker, Jeffrey D. Spitler	Wiley Indian Private Ltd.	
Reference Books				
1	Radiant Heating and Cooling Handbook	Richard D. Watson	McGraw-Hill Publication	2002
Link: https://www.accessengineeringlibrary.com/browse/radiant-heating-and-cooling-handbook#p2000a97e9970iii001				
2	Evaporative Cooling		CAREL	
Link: http://www.carel.com/-evaporative-cooling-book				

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VII
Professional Elective 3

THEORYOF PLASTICITY

Course Code	**18ME743**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To introduce the concepts of Plasticity and mechanism of plastic deformation in metals.
- To expose the students to elasto-plastic problems involving plastic deformation of beams and bars.
- To introduce the concepts of slip line field theory.

Module-1

Brief review of fundamentals of elasticity: Concept of stress, stress invariants, principal Stresses, octahedral normal and shear stresses, spherical and deviatoric stress, stress transformation; concept of strain, engineering and natural strains, octahedral strain, deviator and spherical strain tensors, strain rate and strain rate tensor, cubical dilation, generalized Hooke's law, numerical problems.

Module-2

Plastic Deformation of Metals: Crystalline structure in metals, mechanism of plastic deformation, factors affecting plastic deformation, strain hardening, recovery, re crystallization and grain growth, flow figures or Luder's cubes.

Yield Criteria: Introduction, yield or plasticity conditions, Von Mises and Tresca criterion, geometrical representation, yield surface, yield locus (two-dimensional stress space), experimental evidence for yield

Module-3

Stress Strain Relations: Idealised stress-strain diagrams for different material models, empirical equations, Levy-Von Mises equation, Prandtl -Reuss and Saint Venant theory, experimental verification of Saint Venant's theory of plastic flow. Concept of plastic potential, maximum work hypothesis, mechanical work for deforming a plastic substance.

Module-4

Bending of Beams: Stages of plastic yielding, analysis of stresses, linear and nonlinear stress strain curve, problems.

Torsion of Bars: Introduction, plastic torsion of a circular bar, elastic perfectly plastic material, elastic work hardening of material, problems.

Module-5

Slip Line Field Theory: Introduction, basic equations for incompressible two-dimensional flows, continuity equations, stresses in conditions of plain strain, convention for slip lines, geometry of slip line field, properties of the slip lines, construction of slip line nets.

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

CO1: Understand stress, strain, deformations, relation between stress and strain and plastic deformation in solids.

CO2: Understand plastic stress-strain relations and associated flow rules.

CO3: Perform stress analysis in beams and bars including Material nonlinearity.

CO4: Analyze the yielding of a material according to different yield theory for a given state of stress.

CO5: Interpret the importance of plastic deformation of metals in engineering problems.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.

- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Theory of Plasticity	Chakraborty	Elsevier	3rd Edition
2	Theory of Plasticity and Metal forming Process	Sadhu Singh	Khanna Publishers, Delhi	
Reference Books				
1	Engineering Plasticity-Theory and Application to Metal Forming Process	R.A.C. Slater	McMillan Press Ltd.	
2	Basic Engineering Plasticity	DWA Rees	Elsevier	1st Edition
3	Engineering Plasticity	W. Johnson and P. B. Mellor	Van NoStrand Co. Ltd	2000
4	Advanced Mechanics of solids	L. S. Srinath	Tata Mc. Graw Hill	2009

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VII
Professional Elective 3

MECHATRONICS

Course Code	**18ME744**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To acquire a strong foundation in science and focus in mechanical, electronics, control, software, and computer engineering, and a solid command of the newest technologies.
- To understand the evolution and development of Mechatronics as a discipline.
- To substantiate the need for interdisciplinary study in technology education
- To understand the applications of microprocessors in various systems and to know the functions of each element.
- To demonstrate the integration philosophy in view of Mechatronics technology
- To be able to work efficiently in multidisciplinary teams.

Module-1

Introduction: Scope and elements of mechatronics, mechatronics design process, measurement system, requirements and types of control systems, feedback principle, Basic elements of feedback control systems, Classification of control system. Examples of Mechatronics Systems such as Automatic Car Park system, Engine management system, Antilock braking system (ABS) control, Automatic washing machine.
Transducers and sensors: Definition and classification of transducers, Difference between transducer and sensor, Definition and classification of sensors, Principle of working and applications of light sensors, Potentiometers, LVDT, Capacitance sensors, force and pressure sensors, Strain gauges, temperature sensors, proximity switches and Hall Effect sensors.

Module-2

Signal Conditioning: Introduction – Hardware – Digital I/O, Analog to digital conversions, resolution, Filtering Noise using passive components – Registers, capacitors, amplifying signals using OP amps. Digital Signal Processing – Digital to Analog conversion, Low pass, high pass, notch filtering. Data acquisition systems (DAQS), data loggers, Supervisory control and data acquisition (SCADA), Communication methods.
Electro Mechanical Drives: Relays and Solenoids – Stepper Motors – DC brushed motors – DC brushless motors – DC servo motors – 4-quadrant servo drives, PWM's – Pulse Width Modulation.

Module-3

Microprocessor & Microcontrollers: Introduction, Microprocessor systems, Basic elements of control systems, Microcontrollers, Difference between Microprocessor and Microcontrollers.
Microprocessor Architecture: Microprocessor architecture and terminology-CPU, memory and address, I/O and Peripheral devices, ALU, Instruction and Program, Assembler, Data Registers, Program Counter, Flags, Fetch cycle, write cycle, state, bus interrupts. Intel's 8085A Microprocessor.

Module-4

Programmable Logic Controller: Introduction to PLCs, Basic structure of PLC, Principle of operation, input and output processing, PLC programming language, ladder diagram, ladder diagrams circuits, timer counters, internal relays, master control, jump control, shift registers, data handling, and manipulations, analogue input and output, selection of PLC for application.
Application of PLC control: Extending and retracting a pneumatic piston using latches, control of two pneumatic pistons, control of process motor, control of vibrating machine, control of process tank, control of conveyer motor etc.

Module-5

Mechatronics in Computer Numerical Control (CNC) machines: Design of modern CNC machines - Machine Elements: Different types of guide ways, Linear Motion guideways. Bearings: anti-friction bearings,

hydrostatic bearing and hydrodynamic bearing. Re-circulating ball screws. Typical elements of open and closed loop control systems. Adaptive controllers for machine tools.

Mechatronics Design process: Stages of design process – Traditional and Mechatronics design concepts – Case studies of Mechatronics systems – Pick and place Robot – Automatic car park barrier.

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

CO1: Illustrate various components of Mechatronics systems.

CO2: Assess various control systems used in automation.

CO3: Design and conduct experiments to evaluate the performance of a mechatronics system or component with

respect to specifications, as well as to analyse and interpret data.

CO4: Apply the principles of Mechatronics design to product design.

CO5: Function effectively as members of multidisciplinary teams.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Mechatronics-Principles Concepts and Applications	Nitaigour Premchand Mahalik	Tata McGraw Hill	1st Edition, 2003
2	Mechatronics–Electronic Control Systems in Mechanical and Electrical Engineering,	W.Bolton	Pearson Education	1stEdition, 2005
Reference Books				
1	Mechatronics	HMT Ltd	Tata Mc Graw Hill	1st Edition, 2000 ISBN:978007 4636435
2	Mechatronics: Integrated Mechanical Electronic Systems	K.P. Ramachandran, G.K. Vijayaraghavan, M.S. Balasundaram.	Wiley India Pvt. Ltd. New Delhi	2008
3	Introduction to Mechatronics and Measurement Systems	David G. Aldatore, Michael B. Histand	McGraw-Hill Inc USA	2003
4	Introduction to Robotics: Analysis, Systems, Applications.	Saeed B. Niku,	Person Education	2006
5	Mechatronics System Design	Devdas Shetty, Richard A. kolk	Cengage publishers.	second edition

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VII
Professional Elective 3

PROJECT MANAGEMENT

Course Code	**18ME745**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand how to break down a complex project into manageable segments and use of effective project management tools and techniques to arrive at solution and ensure that the project meets its deliverables and is completed within budget and on schedule.
- To impart knowledge on various components, phases, and attributes of a project.
- To prepare students to plan, develop, lead, manage, and successfully implement and deliver projects within their chosen practice area.

Module-1

Introduction: Definition of project, characteristics of projects, understand projects, types of projects, scalability of project tools, project roles Project Selection and Prioritization – Strategic planning process, Strategic analysis, strategic objectives, portfolio alignment – identifying potential projects, methods of selecting projects, financial mode / scoring models to select projects, prioritizing projects, securing and negotiating projects.

Module-2

Planning Projects: Defining the project scope, Project scope checklist, Project priorities, Work Breakdown Structure (WBS), Integrating WBS with organisation, coding the WBS for the information system. Scheduling Projects: Purpose of a project schedule, historical development, how project schedules are limited and created, develop project schedules, uncertainty in project schedules, Gantt chart.

Module-3

Resourcing Projects: Abilities needed when resourcing projects, estimate resource needs, creating staffing management plant, project team composition issues, Budgeting Projects: Cost planning, cost estimating, cost budgeting, establishing cost control. Project Risk Planning: Risk Management Planning, risk identification, risk analysis, risk response planning, Project Quality Planning and Project Kick off: Development of quality concepts, project quality management plan, project quality tools, kick off project, baseline and communicate project management plan, using Microsoft Project for project baselines.

Module-4

Performing Projects: Project supply chain management: - Plan purchasing and acquisitions, plan contracting, contact types, project partnering and collaborations, project supply chain management. 28 Project Progress and Results: Project Balanced Scorecard Approach, Internal project, customer, financial issues, Finishing the project: Terminate project early, finish projects on time, secure customer feedback and approval, knowledge management, perform administrative and contract closure.

Module-5

Network Analysis: Introduction, network construction - rules, Fulkerson's rule for numbering the events, AON and AOA diagrams; Critical path method (CPM) to find the expected completion time of a project, floats; PERTfor finding expected duration of an activity and project, determining the probability of completing a project, predicting the completion time of project; crashing of simple projects.

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

CO1: Understand the selection, prioritization and initiation of individual projects and strategic role of project management.

CO2: Understand the work breakdown structure by integrating it with organization.

CO3: Understand the scheduling and uncertainty in projects.

CO4: Understand risk management planning using project quality tools.
CO5: Understand the activities like purchasing, acquisitions, contracting, partnering and collaborations related to performing projects.
CO6: Determine project progress and results through balanced scorecard approach
CO7: Draw the network diagram to calculate the duration of the project and reduce it using crashing.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Project Management	Timothy J Kloppenborg	Cengage Learning	Edition 2009
2	Project Management -A systems approach to planning scheduling and controlling	Harold kerzner	CBS publication	
3	Project Management	S Choudhury	McGraw Hill Education (India) Pvt. Ltd. New Delhi	2016
Reference Books				
1	Project Management	Pennington Lawrence	Mc Graw Hill	
2	Project Management	A Moder Joseph and Phillips New Yark	Van Nostrand Reinhold	
3	Project Management,	Bhavesh M. Patal	Vikas publishing House	

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)

Open Elective-B (Semester VII)

ENERGY AND ENVIRONMENT

Course Code	**18ME751**	CIE Marks	40
Teaching Hours / Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the fundamentals of energy sources, energy use, energy efficiency, and resulting environmental implications of various energy supplies.
- To introduce various aspects of environmental pollution and its control.
- To understand the causes and remedies related to social issues like global warming, ozone layer depletion, climate change etc.
- To introduce various acts related to prevention and control of pollution of water and air, forest protection act, wild life protection act etc.

Module-1

Basic Introduction to Energy: Energy and power, forms of energy, primary energy sources, energy flows, world energy production and consumption, Key energy trends in India: Demand, Electricity, Access to modern energy, Energy production and trade, Factors affecting India's energy development: Economy and demographics Policy and institutional framework, Energy prices and affordability, Social and environmental aspects, Investment.

Module-2

Energy storage systems: Thermal energy storage methods, Energy saving, Thermal energy storage systems
Energy Management: Principles of Energy Management, Energy demand estimation, Energy pricing
Energy Audit: Purpose, Methodology with respect to process Industries, Characteristic method employed in Certain Energy Intensive Industries

Module-3

Environment: Introduction, Multidisciplinary nature of environmental studies- Definition, scope and importance, Need for public awareness.
Ecosystem: Concept, Energy flow, Structure and function of an ecosystem. Food chains, food webs and ecological pyramids, Forest ecosystem, Grassland ecosystem, Desert ecosystem and Aquatic ecosystems, Ecological succession.

Module-4

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

Module-5

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

Group assignments:
Assignments related to e-waste management; Municipal solid waste management; Air pollution control systems; Water treatment systems; Wastewater treatment plants; Solar heating systems; Solar power plants; Thermal power plants; Hydroelectric power plants; Biofuels; Environmental status assessments; Energy status assessments etc.

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

CO1: Understand energy scenario, energy sources and their utilization.
CO2: Understand various methods of energy storage, energy management and economic analysis.
CO3: Analyse the awareness about environment and eco system.
CO4: Understand the environment pollution along with social issues and acts.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Textbook for Environmental Studies for Undergraduate Courses of all Branches of Higher Education		University grant commission and Bharathi Vidyapeeth Institute of environment education and Research, Pune	
2	Energy Management Audit & Conservation- for Module 2	Barun Kumar De	Vrinda Publication	2nd Edition 2010
Reference Books				
1	Energy Management Hand book	Turner, W. C., Doty, S. and Truner, W. C	Fairmont Press	7th Edition 2009
2	Energy Management	Murphy, W. R	Elsevier	2007
3	Energy Management Principles	Smith, C. B	Pergamum	2007
4	Environment pollution control Engineering	C S Rao	New Age International	reprint 2015, 2nd edition
5	Environmental studies	Benny Joseph	Tata McGraw Hill	2nd edition 2008

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)

Semester VIII Open Elective B

AUTOMOTIVE ENGINEERING

Course Code	**18ME752**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To know layout and arrangement of principal parts of an automobile.
- To understand the working of transmission and brake systems.
- To comprehend operation and working of steering and suspension systems.
- To know the Injection system and its advancements.
- To know the automobile emissions and its effects on environment.

Module-1

ENGINE COMPONENTS AND IT'S PRINCIPLE PARTS: Spark Ignition (SI) & Compression Ignition (CI) engines, cylinder – arrangements and their relatives merits, Liners, Piston, connecting rod, crankshaft, valves, valve actuating mechanisms, valve and port timing diagrams, Types of combustion chambers for S.I.Engine and C.I.Engines, methods of a Swirl generation, engine positioning. Concept of HCCI engines, Hybrid engines, Twin spark engine, Electric car.

COOLING AND LUBRICATION: Cooling requirements, Types of cooling- Thermo siphon system, Forced circulation water cooling system, Water pump, Radiator, Significance of lubrication, Splash and Forced feed system.

Module-2

TRANSMISSION SYSTEMS: Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, Over drive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints. Differential and rear axle, Hotchkiss Drive and Torque Tube Drive.

BRAKES: Types of brakes, mechanical compressed air, vacuum and hydraulic braking systems, construction and working of master and wheel cylinder, brake shoe arrangements, Disk brakes, drum brakes, Antilock – Braking systems, purpose and operation of antilock-braking system, ABS Hydraulic Unit, Rear-wheel antilock, & Numerical.

Module-3

STEERING AND SUSPENSION SYSTEMS: Steering geometry and types of steering gear box-Power Steering, Types of Front Axle, Suspension, Torsion bar suspension systems, leaf spring, coil spring, independent suspension for front wheel and rear wheel, Air suspension system.

IGNITION SYSTEM: Battery Ignition system, Magneto Ignition system, electronic Ignition system.

Module-4

SUPERCHARGERS AND TURBOCHARGERS: Naturally aspirated engines, Forced Induction, Types of superchargers, Turbocharger construction and operation, Intercooler, Turbocharger lag.

FUELS, FUEL SUPPLY SYSTEMS FOR SI AND CI ENGINES: Conventional fuels, Alternative fuels, Normal and Abnormal combustion, Cetane and Octane numbers, Fuel mixture requirements for SI engines, Types of carburetors, C.D.& C.C. carburettors, Multi point and Single point fuel injection systems, fuel transfer pumps, Fuel filters, fuel injection pumps and injectors. Electronic Injection system, Common Rail Direct Injection System.

Module-5

AUTOMOTIVE EMISSION CONTROL SYSTEMS: Different air pollutants, formation of photochemical smog and causes. Automotive emission controls, Controlling crankcase emissions, Controlling evaporative emissions, Cleaning the exhaust gas, Controlling the air-fuel mixture, Controlling the combustion process, Exhaust gas recirculation, Treating the exhaust gas, Air-injection system, Air-aspirator system, Catalytic converter.
EMISSION STANDARDS: Euro I, II, III and IV norms, Bharat Stage II, III, IV norms. Motor Vehicle Act.

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

- Identify the different parts of an automobile and it's working.
- Understand the working of transmission and braking systems.
- Understand the working of steering and suspension systems and their applications.
- Selection and applications of various types of fuels and injection systems.
  Analyse the cause of automobile emissions, its effects on environment and methods to reduce the emissions.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Automobile engineering Vol I and II	Kirpal Singh	Standard Publishers	12th Edition 2011
2	Automotive Mechanics	S. Srinivasan	Tata McGraw Hill	2003 2nd Edition
Reference Books				
1	Automotive Mechanics	William H Crouse & Donald L Anglin	Tata McGraw Hill Publishing Company	10th Edition 2007
2	Automotive Mechanics: Principles and Practices,	Joseph Heitner	D Van Nostrand Company, Inc	
3	Automobile Engineering	R. B. Gupta	Satya Prakashan	4thedition 1984.
4	Fundamentals of Automobile Engineering	K.K.Ramalingam	Scitech Publications (India) Pvt. Ltd	

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)

Semester VII Open Elective-B

INDUSTRIAL SAFETY

Course Code	**18ME753**	CIE Marks	40
Teaching Hours / Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- The present course highlights the importance of general safety and its prevention.
- It enables students to understand about mechanical, electrical sand chemical safety.
- The Industrial safety course helps in motivating the students to understand the reason for fire
- Its Controlling of fire by various means are highlighted.
- Importance of chemical safety, labelling of chemicals, hand signals during forklift operations in industrial and aerodromes will help in to understand and apply the techniques in practical field.
- A visit to campus, various labs, workshops, local industries and fire stations helps in analyzing the importance of safety and corrective measures through case studies.

Module-1

Terms used: accident, safety, hazard, safe, safety devices, safety guard, security, precaution, caution, appliance, slip, trip, fall. Ladders and scaffolding. Unsafe acts, reason for accidents, MSDS (material safety data sheet), computer Aided Hazard Analysis, International acts and standards OSHA, WHO. Environment act, control and abatement of environmental pollution-Biomedical waste. Lockout and tag out procedures. Safe material handling and storage. Risk analysis quantification.

Case studies: Student should identify the unsafe acts near their surroundings like housekeeping, lab as well as industrial layouts, road safety, campus layout, safety signs.

Module-2

Introduction, toxicity of products of combustion – vapour clouds – flash fire – jet fires – pool fires – auto-ignition, sources of ignition . Class A, B, C, D and E fire. Fire triangle, Fire extinguishers, Fire hazard and analysis, prevention of fire. Fire protection and loss prevention, steps after occurrence of fire. notice-first aid for burns, Portable fire extinguishers. Fire detection, fire alarm and firefighting systems. Safety sign boards, instruction on portable fire extinguishers. Case studies: demonstration of fire extinguishers, visit to local fire fighting stations. Visit to fire accident sites to analyze the cause of fire and its prevention for future.

Module-3

PPE, safety guards, Mechanical hazards, workplace hazards, Forklift hazard control Safety while working with machine tools like lathe, drill press, power and band saws, grinding machines. Safety during welding, forging and pressing. Safety while handling Material, compressed gas cylinders, corrosive substance, waste drum and containers.

Case studies: Visit to machine shop, workshops, foundry lab and local industries to record the practical observation and report the same with relevant figures and comments.

Module-4

Introduction to electrical safety, Indian standards on electrical safety, Electric hazards, effect of electric current on human body, causes of electrical accidents, prevention of electric accidents, PPE used. Protection systems: Fuse, circuit breakers and overload relays – protection against over voltage and under voltage. Electric shock. Primary and secondary electric shocks, AC and DC current shocks. Safety precautions against shocks. Safety precautions in small and residential building installations. Safety procedures in electric plant.

Case studies: To visit electrical sub stations, local distribution systems, observe and share the experience and report.

Module-5

Introduction to Chemical safety, Labelling of chemicals, acid hoods. Handling of acids, eye washers and showers. Safety thinking, accident investigation, safety policy of the company, safety, loss prevention and control, check list for LPG installations, safety precautions using CNG, fire prevention and safety audit, confined space entry, risk assessment.

Case studies: To visit chemical laboratory of the college and other chemical industries like LPG , CNG facilities and report.

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

CO1: Understand the basic safety terms and international standards.

CO2: Identify the hazards and risk analysis around the work environment and industries.

CO3: Use the safe measures while performing work in and around the work area of the available laboratories. Able to recognize the sign boards and its application

CO4: Recognise the types of fires extinguishers and to demonstrate the portable extinguishers used for different classes of fires.

CO5: Report the case studies by sharing experience of the employees working in housekeeping, laboratories like workshops, electrical labs, machine shops, electronics and computer laboratories.

CO6: Recognise the chemical and electrical hazards for its prevention and control.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Industrial Safety and Management	L M Deshmukh	McGraw Hill Education (India) private Limited	ISBN-13: 978-0-07-061768-1
2	Fire Prevention Hand Book	Derek, James	Butter Worth's and Company, London	1986
3	Electrical Safety, fire safety and safety management	S.Rao, R K Jain and Saluja	Khanna Publishers	ISBN: 978-81-7409-306-6
4	Industrial health and safety management	A.M.Sarma	Himalya publishing house	
5	Chemical process Industrial safety	K S N Raju	McGraw Hill Education (India) private Limited.	ISBN-13: 978-93-329-0278-7
6	Environmental engineering	Gerard Kiely	McGraw Hill Education (India) private Limited	ISBN-13: 978-0-07-063429-9
Reference Books				
1	The Environment Act (Protection) 1986	Commercial Law Publishers (India) Pvt. Ltd. New Delhi.		
2	Water (Prevention and control of pollution) act 1974	Commercial Law publishers (India)		

		Pvt. Ltd., New Delhi.		
• To visit respective Institution: stores, office, housekeeping area, laboratories. • To visit local industries, workshops, district firefighting system facility and local electrical power stations.				

OPEN ELECTIVE B

B. E. MECHANICAL ENGINEERING

Choice Based Credit System (CBCS) and Outcome Based Education (OBE)

SEMESTER – VII

OPTIMISATION TECHNIQUES

Course Code	**18ME754**	CIE Marks	40
Teaching Hours / Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To expose the students to techniques to optimize complex engineering problems.
- To introduce non-linear programming techniques.
- To introduce the Integer programming method.

Module-1

Introduction: Statement of optimisation problem, Design vector, Design constraints, Objective function, Classification of optimisation problems based on :constraints, nature of design variables, nature of the equations involved

Single variable optimisation: Necessary and sufficient conditions, Multivariable optimization with no constraints: Necessary and sufficient conditions, Semi definite case, Saddle point, Multi variable optimization with equality constraints, Solution by direct substitution, Lagrange Multipliers, Interpretation of Lagrange multipliers, Multivariable optimization with inequality constraints: Khun Tucker conditions(concept only).

Module-2

Nonlinear Programming: One-Dimensional Minimization Methods**,** Introduction, Unimodal Function, Elimination methods: unrestricted search, fixed step size, accelerated step size, Exhaustive search: dichotomous search, interval halving method, Fibonacci method, golden section method, Interpolation methods: Quadratic and cubic interpolation method, direct root method, Newton method, Quasi-Newton method, secant method.

Module-3

Nonlinear Programming: Direct search methods: Classification of unconstrained minimization methods, rate of convergence, scaling of design variables, random search methods, univariate methods, pattern directions, Powell's methods, Simplex method.

Module-4

Nonlinear Programming: Indirect Search (Descent) Methods: Gradient of a function, Steepest decent method, Fletcher Reeves method, Newton's method, Davidson-Fletcher-Powell method.

Module-5

Integer Programming: Introduction, Graphical representation, Gomory's cutting plane method: concept of a cutting plane, Gomory's method for all-integer programming problems, Bala's algorithm for zero–one programming, Branch-and-Bound Method.

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

CO1: Define and use optimization terminology, concepts, and understand how to classify an optimization problem.

CO2: Understand how to classify an optimization problem.

CO3: Apply the mathematical concepts formulate the problem of the systems.

CO4: Analyse the problems for optimal solution using the algorithms.

CO5: Interpret the optimum solution.

Question paper pattern:

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

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Engineering Optimization Theory and Practice	S. S. Rao	John Wiley & Sons	Fourth Edition 2009
2	Optimisation Concepts and Applications in Engineering	A. D. Belegundu, T.R. Chanrupatla,	Cambridge University Press	2011
Reference Books				
1	Engineering Optimization: Methods and Applications	Ravindran, K. M. Ragsdell, and G. V. Reklaitis	Wiley, New York	2nd ed. 2006

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

COMPUTRE AIDED MANUFACTURING LAB

Course Code	**18MEL76**	CIE Marks	40
Teaching Hours /Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To expose the students to the techniques of CNC programming and cutting tool path generation through CNC simulation software by using G-Codes and M-codes.
- To educate the students on the usage of CAM packages.
- To make the students understand the importance of automation in industries through exposure to FMS, Robotics, and Hydraulics and Pneumatics.

Sl. No.	Experiments
	PART - A
1	**Manual CNC part programming** using ISO Format G/M codesfor 2 turning and 2 milling parts. Selection and assignment of tools, correction of syntax and logical errors, and verification of tool pathusing CNC program verification software.
	PART - B
2	**CNC part programming using CAM packages**. Simulation of Turning, Drilling, Milling operations. 3 typical simulations to be carried out using simulation packages like: **CademCAMLab-Pro, Master-CAM.** Program generation using software. Optimize spindle power, torque utilization, and cycle time. Generation and printing of shop documents like process and cycle time sheets, tool list, and tool layouts. Cut the part in single block and auto mode and measure the virtual part on screen. **Post processingof CNC programs** for standard CNC control systems like **FANUC, SINUMERIC and MISTUBISHI.**
	PART - C
3	**(Only for Demo/Viva voce)** **FMS (Flexible Manufacturing System)**: Programming of Automatic storage and Retrieval system (ASRS) and linear shuttle conveyor Interfacing CNC lathe, milling with loading unloading arm and ASRS to be carried out on simple components. **Robot programming:** Using Teach Pendent & Offline programming to perform pick and place, stacking of objects (2 programs). **Pneumatics and Hydraulics, Electro-Pneumatics:** 3 typical experiments on Basics of these topics to be conducted.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.

Scheme of Examination:

One question from Part A: 40 marks

One question from Part B: 40 Marks

Viva voce: 20 Marks

Total: 100 Marks

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

DESIGN LAB

Course Code	**18MEL77**	CIE Marks	40
Teaching Hours /Week (L:T:P)	0:2:2	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To understand the concepts of natural frequency, logarithmic decrement, damping and damping ratio.
- To understand the techniques of balancing of rotating masses.
- To verify the concept of the critical speed of a rotating shaft.
- To illustrate the concept of stress concentration using Photo elasticity.
- To appreciate the equilibrium speed, sensitiveness, power and effort of a Governor.
- To illustrate the principles of pressure development in an oil film of a hydrodynamic journal bearing.

Sl. No.	Experiments
	PART - A
1	Determination of natural frequency, logarithmic decrement, damping ratio and damping coefficient in a single degree of freedom vibrating systems (longitudinal and torsional).
2	Balancing of rotating masses
3	Determination of critical speed of a rotating shaft
4	Determination of equilibrium speed, sensitiveness, power and effort of Porter/Proell /Hartnel Governor.
	PART - B
5	Determination of Fringe constant of Photo-elastic material using. a) Circular disc subjected to diametral compression. b) Pure bending specimen (four-point bending.
6	Determination of stress concentration using Photo-elasticity for simple components like plate with a hole under tension or bending, circular disk with circular hole under compression, 2D Crane hook
7	Determination of Pressure distribution in Journal bearing
8	Determination of Principal Stresses and strains in a member subjected to combined loading using Strain
9	Determination of stresses in Curved beam using strain gauge.

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

CO1: Compute the natural frequency of the free and forced vibration of single degree freedom systems, critical speed of shafts.

CO2: Carry out balancing of rotating masses.

CO3: Analyse the governor characteristics.

CO4: Determine stresses in disk, beams, plates and hook using photo elastic bench.

CO5: Determination of Pressure distribution in Journal bearing

CO6: Analyse the stress and strains using strain gauges in compression and bending test and stress distribution in curved beams.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners

Scheme of Examination:
One question from Part A: 40 marks
One question from Part B: 40 Marks
Viva voce: 20 Marks
Total: 100 Marks

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VIII

ENERGY ENGINEERING

Course Code	**18ME81**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand energy scenario, energy sources and their utilization
- Learn about energy conversion methods
- Study the principles of renewable energy conversion systems.

Module-1

STEAM GENERATORS Coal and ash handling, Generation of steam using forced circulation, high and supercritical pressures, LaMount, Benson, Velox, Loeffer, Schmidt steam generators, Cooling towers and Ponds, Accessories such as Superheaters, De-superheater, Economizers, Air preheaters.

Module-2

Solar Energy: Introduction, Solar radiation at the earth's surface, Solar radiation measurements, Flat plate collectors, Focussing collectors, Solar pond, Solar electric power generation-Solar photovoltaics.
Biomass Energy: Photosynthesis, photosynthetic oxygen production, energy plantation. Bio Chemical Route: Biogas production from organic wastes by anaerobic fermentation, Bio gas plants-KVIC, Janta, Deenbhandu models, factors affecting bio gas generation. Thermal gasification of biomass, updraft and downdraft

Module-3

Geothermal Energy: Forms of geothermal energy, Dry steam, wet steam, hot dry rock and magmatic chamber systems.
Tidal Energy: Tidal power, Site selection, Single basin and double basin systems, Advantages and disadvantages of tidal energy.
Wind Energy: Wind energy-Advantages and limitations, wind velocity and wind power, Basic components of wind energy conversion systems, horizontal and vertical axis wind mills, coefficient of performance of a wind mill rotor, Applications of wind energy.

Module-4

Hydroelectric plants: Advantages & disadvantages of water power, Hydrographs and flow duration curves-numericals, Storage and pondage, General layout of hydel power plants- components such as Penstock, surge tanks, spill way and draft tube and their applications, pumped storage plants, Detailed classification of hydroelectric plants, water hammer.
Ocean Thermal Energy: Ocean thermal energy conversion, Principle and working of Rankine cycle, Problems associated with OTEC.

Module-5

NUCLEAR ENERGY Principles of release of nuclear energy-Fusion and fission reactions. Nuclear fuels used in the reactors, Chain reaction, Moderation, breeding, Multiplication and thermal utilization factors. General components of a nuclear reactor and materials, Brief description-Pressurized water reactor, Boiling water reactor, Sodium graphite reactor, Fast Breeder reactor, Homogeneous graphite reactor and gas cooled reactor, Radiation hazards, Shielding, Nuclear waste, Radioactive waste disposal.

Course Outcomes: At the end of the course the student will be able to:
CO1: Understand the construction and working of steam generators and their accessories.

CO2: Identify renewable energy sources and their utilization.

CO3: Understand principles of energy conversion from alternate sources including wind, geothermal, ocean, biomass, nuclear, hydel and tidal.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Power Plant Engineering	P. K. Nag	Tata McGraw Hill Education Private Limited, New Delhi	Third Edition, 2012.
2	Power Plant Engineering	Arora and Domkundwar	Dhanpat Rai & Co. (P) Ltd.	Sixth Edition, 2012.
3	Non-conventional Sources of Energy	G.D.Rai	Khanna Publishers, New Delhi	Fifth Edition, 2015.
4	Non-conventional energy resources	B H Khan	McGraw Hill Education	3rd Edition
Reference Books				
1	Power Plant Engineering	R. K. Rajput	Laxmi publication New Delhi	
2	Principles of Energy conversion	A. W. Culp Jr	McGraw Hill	1996
3	Power Plant Technology	M.M. EL-Wakil	McGraw Hill International	1994
4	Solar Energy: principles of Thermal Collection and Storage	S.P. Sukhatme	Tata McGraw-Hill	1984

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VIII
Professional Elective-4

CNC MACHINE TOOLS

Course Code	**18ME821**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand fundamentals of the CNC technology.
- To get exposed to constructional features of CNC machine tools.
- To know the concepts of CNC machine tool drives and feedback systems.
- To understand the programming methods in CNC machines.
- To understand the cutting tools used, and work holding devices on CNC machine tools.

Module-1

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.

Module-2

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.

Module-3

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.

Module-4

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, manual part programming for machining centre and turning centre.

Computer Aided CNC Part Programming: Need for computer aided part programming, Tools for computer aided part programming, APT, CAD/CAM based part programming for well-known controllers such as Fanuc, Heidenhain, Sinumerik etc., and generation of CNC codes from CAM packages.

Module-5

TOOLING AND WORK HOLDING DEVICES: Introduction to cutting tool materials – Carbides, Ceramics, CBN, PCD–inserts classification, qualified, semi qualified and pre-set tooling, tooling system for Machining centre and Turning centre, work holding devices for rotating and fixed work parts, modular fixtures, economics of CNC, maintenance of CNC machines.

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

CO1: Understand evolution, classification and principles of CNC machine tools.

CO2: Learn constructional details of CNC machine tools, selection of standard components used for CNC machine tools for accuracy and productivity enhancement.

CO3: Select drives and positional transducers for CNC machine tools.

CO4: Apply CNC programing concepts of for two axis turning centers and three axis vertical milling centers to generate programs different components.

CO5: Generate CNC programs for popular CNC controllers.

CO6: Analyse and select tooling and work holding devices for different components to be machined on CNC machine tools.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Mechatronics	HMT	Tata McGraw-Hill Publishing Company Limited, New Delhi	2005
2	Computer Control of Manufacturing systems	Koren Y	McGraw Hill	1986
3	Computer Numerical Control Machines	Radhakrishnan P	New Central Book Agency	2002
Reference Books				
1	CNC Machining Hand Book	James Madison	Industrial Press Inc	1996
2	Programming of CNC Machines	Ken Evans, John Polywka& Stanley Gabrel	Industrial Press Inc, New York	Second Edition2002
3	CNC Programming Hand book	Peter Smid	Industrial Press Inc	2000
4	CAD/CAM	Rao P.N.	Tata McGraw-Hill Publishing Company Limited	2002
5	Computer Numerical Control	Warren S. Seames	Thomson Delmar	Fourth Edition 2002

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VIII
Professional Elective-4

TRIBOLOGY

Course Code	**18ME822**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To educate the students on the importance of friction, the related theories/laws of sliding and rolling friction and the effect of viscosity of lubricants.
- To expose the students to the consequences of wear, wear mechanisms, wear theories and analysis of wear problems.
- To make the students understand the principles of lubrication, lubrication regimes, theories of hydrodynamic and the advanced lubrication techniques.
- To expose the students to the factors influencing the selection of bearing materials for different sliding applications.
- To introduce the concepts of surface engineering and its importance in tribology.

Module-1

Introduction to tribology: Historical background, practical importance, and subsequent use in the field.
Lubricants: Types and specific field of applications. Properties of lubricants, viscosity, its measurement, effect of temperature and pressure on viscosity, lubrication types, standard grades of lubricants, and selection of lubricants.

Module-2

Friction: Origin, friction theories, measurement methods, friction of metals and non-metals.
Wear: Classification and mechanisms of wear, delamination theory, debris analysis, testing methods and standards. Related case studies.

Module-3

Hydrodynamic journal bearings: Friction forces and power loss in a lightly loaded journal bearing, Petroff's equation, mechanism of pressure development in an oil film, and Reynold's equation in 2D.
Introduction to idealized journal bearing, load carrying capacity, condition for equilibrium, Sommerfeld's number and it's significance; partial bearings, end leakages in journal bearing, numerical examples.

Module-4

Plane slider bearings with fixed/pivoted shoe: Pressure distribution, Load carrying capacity, coefficient of friction, frictional resistance in a fixed/pivoted shoe bearing, center of pressure, numerical examples.
Hydrostatic Lubrication: Introduction to hydrostatic lubrication, hydrostatic step bearings, load carrying capacity and oil flow through the hydrostatic step bearing, numerical examples. Introduction to Hydrostatic journal bearings.

Module-5

Bearing Materials: Commonly used bearings materials, and properties of typical bearing materials. Advantages and disadvantages of bearing materials.
Introduction to Surface engineering: Concept and scope of surface engineering.
Surface modification – transformation hardening, surface melting, thermo chemical processes.
Surface Coating – plating, fusion processes, vapor phase processes. Selection of coating for wear and corrosion resistance.

Course Outcomes: At the end of the course, the student will be able to:
CO1: Understand the fundamentals of tribology and associated parameters.
CO2: Apply concepts of tribology for the performance analysis and design of components experiencing relative

motion.

CO3: Analyse the requirements and design hydrodynamic journal and plane slider bearings for a given application.

CO4: Select proper bearing materials and lubricants for a given tribological application.

CO5: Apply the principles of surface engineering for different applications of tribology.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Introduction to Tribology	B. Bhushan	John Wiley & Sons, Inc., New York	2002
2	Engineering Tribology	Prasanta Sahoo	PHI Learning Private Ltd, New Delhi	2011
3	Engineering Tribology	J. A. Williams	Oxford Univ. Press	2005
Reference Books				
1	Introduction to Tribology in bearings	B. C. Majumdar	Wheeler Publishing	
2	Engineering Tribology	G. W. Stachowiak and A. W. Batchelor	Butterworth-Heinemann	1992
3	Friction and Wear of Materials	Ernest Rabinowicz	John Wiley &Sons	1995
4	Basic Lubrication Theory	A. Cameron	Ellis Hardwoods Ltd., UK	
5	Handbook of tribology: materials, coatings and surface treatments	B.Bhushan, B.K. Gupta	McGraw-Hill	1997

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VIII
Professional Elective-4

NON-DESTRUCTIVE TESTINGAND EVALUATION

Course Code	**18ME823**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To introduce the basic principles, techniques, equipment, applications and limitations of Non-Destructive Testing (NDT) methods such as Visual, Penetrant Testing, Magnetic Particle Testing, Ultrasonic Testing, Radiography, Eddy Current.
- To enable selection of appropriate NDT methods.
- To identify advantages and limitations of NDT methods
- To make aware the developments and future trends in NDT.

Module-1

OVERVIEW OF NDT: NDT Versus Mechanical testing, Overview of the Non-Destructive Testing Methods for the detection of manufacturing defects as well as material characterisation. Relative merits and limitations, Various physical characteristics of materials and their applications in NDT. Visual inspection – Unaided and aided.

Module-2

SURFACE NDT METHODS: Liquid Penetrant Testing – Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, inspection materials, magnetization methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.

Module-3

THERMOGRAPHY AND EDDY CURRENT TESTING (ET): Thermography- Principles, Contact and non -contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation – infrared radiation and infrared detectors, Instrumentations and methods, applications. Eddy Current Testing-Generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Types of arrangement, Applications, advantages, Limitations, Interpretation/Evaluation.

Module-4

ULTRASONIC TESTING (UT) AND ACOUSTIC EMISSION (AE):
Ultrasonic Testing-Principle, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique –Principle, AE parameters, Applications.

Module-5

RADIOGRAPHY (RT): Principle, interaction of X-Ray with matter, imaging, film and film less techniques, types and use of filters and screens, geometric factors, Inverse square, law, characteristics of films – graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy- Xero-Radiography, Computed Radiography, Computed Tomography.

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

CO1: Classify various 144on-destructive testing methods.

CO2: Check different metals and alloys by visual inspection method.

CO3: Explain and perform non-destructive tests like: Liquid penetrant test, Magnetic particle test, Ultrasonic test, X- ray and Gamma ray radiography, Leak Test, Eddy current test.

CO4: Identify defects using relevant NDT methods.

CO5: Differentiate various defect types and select the appropriate NDT methods for betterevaluation.

CO6: Document the testing and evaluation of the results.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Practical Non-Destructive Testing	Baldev Raj, T.Jayakumar, M.Thavasimuthu	Narosa Publishing House	2009
2	Non-Destructive Testing Techniques	Ravi Prakash	New Age International Publishers	1st revised edition2010
Reference Books				
1	ASM Metals Handbook,"Non-Destructive Evaluation and Quality Control", Volume-17	American Society of Metals,	Metals Park, Ohio, USA,	2000
2	Introduction to Non-destructive testing: a training guide	Paul E Mix,	Wiley	2nd Edition New Jersey, 2005
3	Handbook of Nondestructive evaluation	Charles, J. Hellier	McGraw Hill, New York	2001

ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook,Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing.

B.E, VIII Semester, Mechanical Engineering
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
(Effective from the academic year 2018-19)

Professional Elective-IV
AUTOMOBILE ENGINEERING

Course Code	**18ME824**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- The layout and arrangement of principal parts of an automobile
- The working of transmission and brake systems
- The operation and working of steering and suspension systems
- To know the Injection system and its advancements
- To know the automobile emissions and its effects on environment

Module - 1

ENGINE COMPONENTS AND IT'S PRINCIPLE PARTS: Spark Ignition (SI) & Compression Ignition (CI) engines, cylinder – arrangements and their relatives merits, Liners, Piston, connecting rod, crankshaft, valves, valve actuating mechanisms, valve and port timing diagrams, Types of combustion chambers for S.I.Engine and C.I.Engines, methods of a Swirl generation, choice of materials for different engine components, engine positioning. Concept of HCCI engines, hybrid engines, twin spark engine, electric car. **COOLING AND LUBRICATION**: cooling requirements, types of cooling- thermo siphon system, forced circulation water cooling system, water pump, Radiator, thermostat valves. Significance of lubrication, splash and forced feed system.

Module - 2

TRANSMISSION SYSTEMS: Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, over drive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints,Differential and rear axle, Hotchkiss Drive and Torque Tube Drive. BRAKES: Types of brakes, mechanical compressed air, vacuum and hydraulic braking systems, construction and working of master and wheel cylinder, brake shoe arrangements, Disk brakes, drum brakes, Antilock –Braking systems, purpose and operation of antilock-braking system, ABS Hydraulic Unit, Rear-wheel antilock & Numerical

Module - 3

STEERING AND SUSPENSION SYSTEMS: Steering geometry and types of steering gear box-Power Steering, Types of Front Axle, Suspension, Torsion bar suspension systems, leaf spring, coil spring, independent suspension for front wheel and rear wheel, Air suspension system. IGNITION SYSTEM: Battery Ignition system, Magneto Ignition system, electronic Ignition system

Module - 4

SUPERCHARGERS AND TURBOCHARGERS: Naturally aspirated engines, Forced Induction, Types of superchargers, Turbocharger construction and operation, Intercooler, Turbocharger lag.
FUELS, FUEL SUPPLY SYSTEMS FOR SI AND CI ENGINES: Conventional fuels, alternative fuels,

normal and abnormal combustion, cetane and octane numbers, Fuel mixture requirements for SI engines, types of carburetors, C.D.& C.C. carburetors, multi point and single point fuel injection systems, fuel transfer pumps, Fuel filters, fuel injection pumps and injectors. Electronic Injection system, Common Rail Direct Injection System

Module - 5

AUTOMOTIVE EMISSION CONTROL SYSTEMS: Different air pollutants, formation of photochemical smog and causes. Automotive emission controls, controlling crankcase emissions, controlling evaporative emissions, Cleaning the exhaust gas, Controlling the air-fuel mixture, Controlling the combustion process, Exhaust gas recirculation, Treating the exhaust gas, Air-injection system, Air-aspirator system, Catalytic converter.

EMISSION STANDARDS: Euro I, II, III and IV norms, Bharat Stage II, III, IV norms. Motor Vehicle Act

Course Outcomes:

- To identify the different parts of an automobile and it's working
- To understand the working of transmission and braking systems
- To comprehend the working of steering and suspension systems
- To learn various types of fuels and injection systems
- To know the cause of automobile emissions, its effects on environment and methods to reduce the emissions.

TEXT BOOKS:

1. Automobile engineering, Kirpal Singh, Vol I and II (12th Edition) Standard Publishers 2011
2. Automotive Mechanics, S. Srinivasan, (2nd Edition) Tata McGraw Hill 2003.

REFERENCE BOOKS

1. Automotive mechanics, William H Crouse & Donald L Anglin (10th Edition) Tata McGraw Hill Publishing Company Ltd., 2007.
2. Automotive mechanics: Principles and Practices, Joseph Heitner, D Van Nostrand Company, Inc
3. Fundamentals of Automobile Engineering, K.K.Ramalingam, Scitech Publications (India) Pvt. Ltd.
4. Automobile Engineering, R. B. Gupta, SatyaPrakashan,(4th Edition) 1984.

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VIII
Professional Elective-4

TOOL DESIGN

Course Code	**18ME825**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To develop capability to design and select single point and multipoint cutting tools for various machining operations.
- Exposure to variety of locating and clamping methods available.
- To enable the students to design jigs and fixtures for simple components.
- To expose the students to the design/selection procedure of press tools and die casting dies**.**

Module-1

Introduction to tool design: Tooling, requirements of a tool designer, general tool design procedure, tool engineering functions and its importance to enhance productivity and quality.
Review of cutting tool materials. Tool angles and signature, Carbide inserts grades - ISO designation and applications, tool holders for turning-ISO designation. Solid type tool, brazed tip tool, throwaway indexable insert types, coated carbides and chip breakers.
Design of single point cutting tools: Design of shank dimensions using strength and rigidity considerations for rectangular, square and round cross section and selection of tool geometry.

Module-2

Design of Multi Point Cutting Tools: Types of drills, Drill bit design - elements like back taper, web thickness, land width, margin, flute length and cross section and selection of tool geometry. Re-sharpening of drill bit.
Tool holders for milling, different tapers used for mounting tool holders in milling, ISO designation. Tool mounting systems.
Design of milling cutters: Design of elements like number of teeth and height, circular pitch, body thickness, chamfer width, fillet radius and selection of tool geometry. Profile sharpened and form relieved milling cutters. Re-sharpening of side and face milling cutter and end mill.

Module-3

Jigs and Fixtures: Functions and differences between jigs and fixtures, advantages in mass production, design principles, economics of jigs and fixtures.
Location: 3-2-1 Principle of location, different types of locating elements.
Clamping: Principles of clamping, types of clamping devices, and power clamping.
Drill bushes;
Drill jigs: Different types, exercises of designing jigs for simple components.
Fixture Design: Turning fixtures, milling fixtures, grinding fixtures, fixturing for CNC machining centers, and modular fixtures. Design exercises on fixtures for turning and milling for simple components

Module-4

Press tools: Classification and working of power presses. Concept and calculations of press tonnage and shut height of a press, components of a simple die, press tool operation, die accessories, shearing action in punch & die, clearance, shear on punch and die, Centre of pressure, and strip layout.
Simple, progressive, compound, combination and inverted dies. Design problems on blanking and piercing dies for simple components.
Bending dies – Introduction, bend allowance, spring back, edge bending die design.

Module-5

Drawing dies – Single action, double action and triple action dies, factors affecting drawing and drawing die design. Design of drawing dies for simple components.

Die casting: Die casting alloys, terminology- core, cavity, sprue, slug, fixed and movable cores, finger cams, draft, ejector pins and plates, gate, goose nozzle, over-flow, platten, plunger, runner, vent, water-line etc.
Types of Dies: Single cavity, multi cavity dies, combination dies, unit dies, advantages and disadvantages of types of dies; finishing, trimming and inspection of die casting components, safety, and modern trends in die casting dies.

Assignment:
Course work includes a **ToolDesign project**. Tool design project should enable the students to design a tooling like Jig or a fixture for a simple component, fixture for a simple component on CNC machining centers, design of a simple blanking and piercing die, progressive die, drawing die etc. Any one of these exercises should be given as an assignment. A group of students (maximum number in a group should be 4) should submit assembly drawing and part drawings, completely dimensioned, indicating the necessary manufacturing tolerances, surface finish symbols and geometric tolerances wherever necessary. Tool design project must be completed using appropriate solid modeling software. Computer generated drawings must be submitted. Design calculations must be hand written and should be included in the report. Tool design project should be given due credit in internal assessment.

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

CO1: Select appropriate cutting tools required for producing a component.
CO2: Understand and interpret cutting tool and tool holder designation systems.
CO3: Select suitable locating and clamping devices for a given component for various operations.
CO4: Analyze and design a jig/fixture for a given simple component.
CO5: Understand various press tools and press tool operations.
CO6: Classify and explain various die casting and injection moulding dies.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Tool Design	Cyril Donaldson, George H. Lecain, V.C.Goold,	Mc Graw Hill Education	5th edition, 2017
2	Manufacturing technology	P.N.Rao,	Mc Graw Hill Education	4th edition, 2013
Reference Books				
1	Jigs and Fixtures	P.H.Joshi	Mc Graw Hill Education	3rd edition, 2010
2	Fundamentals of Tool Design	John.G. Nee, William Dufraine, John W. Evans, Mark Hill	Society of Manufacturing Engineers	2010
3	Fundamentals of Tool Design	Frank W.Wilson	PHI publications	
4	An introduction to Jig and Tool design	Kempester M.H.A	VIVA Books Pvt.Ltd.	2004
5	Metal cutting and Tool Design	RanganathB.J	Vikas publishing house	

6	Metal cutting theory and practice	V. Arshinov& G. Alekseev	MIR publishers, Moscow	
7	Design and production of metal cutting tools	Rodin	Beekman publishers	
8	Production Technology	HMT	TataMc Graw Hill	2013.

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VIII
Professional Elective-4

FRACTURE MECHANICS

Course Code	**18ME826**	CIE Marks	40
Teaching Hours /Week (L:T:P)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To expose the students to the fundamentals of mechanics of fracture of materials.
- The students will learn about stress / strain and deformation fields near a crack tip, fracture characterizing parameters like stress intensity factor and J integral and kinetics of fatigue crack growth.
- To expose the students to fundamentals of linear elastic fracture mechanics, nonlinear (Elastic-Plastic) fracture mechanics and fatigue crack growth.
- Exposure to experimental methods for determining the fracture toughness (for example, ASTM standard procedure for JIC testing).
- To learn the mechanism of failure of structures by fatigue crack growth.

Module-1

Fracture mechanics principles: Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, and Griffith's energy balance approach. Fracture mechanics approach to design, NDT and Various NDT methods used in fracture mechanics, Numerical problems. The Airy stress function. Effect of finite crack size. Elliptical cracks, Numerical problems.

Module-2

Plasticity effects: Theory of Plastic deformation, Irwin plastic zone correction. Dugdale's approach. The shape of the plastic zone for plane stress and plane strain cases. The plate thickness effect, numerical problems. Determination of Stress intensity factors and plane strain fracture toughness: Introduction, estimation of stress intensity factors. Experimental method- Plane strain fracture toughness test, The Standard test, size requirements, etc.

Module-3

The energy release rate, Criteria for crack growth. The crack resistance(R curve). Compliance. Tearing modulus. Stability.
Elastic plastic fracture mechanics: Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria. Experimental determination of CTOD. Parameters affecting the critical CTOD.

Module-4

J integral: Use of J integral. Limitation of J integral. Experimental determination of J integral and the parameters affecting J integral.
Dynamics and crack arrest: Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness.

Module-5

Fatigue crack propagation and applications of fracture mechanics: Crack growth and the stress intensity factor. Factors affecting crack propagation. Variable amplitude service loading, Means to provide fail-safety, Paris law, Required information for fracture mechanics approach.

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

CO1: Analyse the effects of crack like defects on the performance of Aerospace, Civil, and Mechanical Engineering structures.

CO2: Apply the concepts of fracture mechanics to select appropriate materials for engineering structures to insure damage tolerance.

CO3: Understand mechanics of crack tip fields and appropriate fracture characterizing parameters like stress intensity factor and J integral or nonlinear energy release rate and how to compute them using various methods.

CO4: Apply the concepts of fracture mechanics to determine critical crack sizes and fatigue crack propagation rates in engineering structures leading to life estimation.

CO5: Understand the status of academic research in field of fracture mechanics.

Question paper pattern:

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

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Elements of fracture mechanics	Prasanth Kumar	Wheeter publication	1999
2	Fracture Mechanics: Fundamentals and Applications	Anderson	CRC press	3rd Ed., 2005
Reference Books				
1	Introduction to fracture mechanics	Karen Hellan	McGraw Hill	2nd Edition
2	Engineering fracture mechanics	S.A. Meguid	Elsevier Applied Science	1989
3	Fracture of Engineering Brittle Materials	Jayatilaka	Applied Science Publishers	1979
4	Fracture and Fatigue Control in Structures	Rolfe and Barsom	Prentice Hall	1977
5	Engineering Fracture Mechanics	Broek	MartinusNijhoff publishers	1982
6	Advanced Fracture Mechanics	M.F.Kanninen and C.H.Popelar	Oxford press	1985