Department of Mechanical Engineering

COURSE PLAN 2018-19

III Semester "B" division

INSTITUTE VISION

"To be a preferred institution in Engineering Education by achieving excellence in teaching and research and to remain as a source of pride for its commitment to holistic development of individual and society"

INSTITUTE MISSION

"To continuously strive for the overall development of students, educating them in a state-of-the-art-infrastructure, by retaining the best practices, people and inspire them to imbibe real time problem solving skills, leadership qualities, human values and societal commitments, so that they emerge as competent professionals"

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

"To be the centre of excellence in providing education in the field of Mechanical Engineering to produce technically competent and socially responsible engineering graduates"

MISSION

"Educating students to prepare them for professional competencies in the broader areas of the Mechanical Engineering field by inculcating analytical skills, research abilities and encouraging culture of continuous learning for solving real time problems using modern tools"

Program Educational Objectives (PEOs)

The Graduates will be able to

PEO1: Acquire core competence in Applied Science, Mathematics and Mechanical Engineering fundamentals to excel in professional career and higher study

PEO2: Design, demonstrate and analyze the mechanical systems which are useful to society.

PEO3: Maintain professional & ethical values, employability skills, multidisciplinary approach & an ability to realize engineering issues to broader social context by engaging in lifelong learning.

Program Specific Outcomes (PSOs)

PSO1: Able to apply the basic principles of Mechanical Engineering in various practical fields to solve societal problems by engaging themselves in many state/national level projects.

PSO2: Able to analyze and design basic mechanical system using relevant tools and techniques.

PSO3: Able to resolve contemporary issues of industries through industry institute interaction and alumni social networks

Program Outcomes (POs)

PO1: **Engineering knowledge-** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: **Problem analysis-** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3:**Design/development of solutions-** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4:**Conduct investigations of complex problems-** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5:**Modern tool usage-** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6:**The engineer and society-** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7:**Environment and sustainability-** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8:**Ethics-** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9:**Individual and team work-** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10:**Communication-** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: **Project management and finance-** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12:**Life-long learning-** Recognize the need for, and have the preparation and ability to engage in

independent and life-long learning in the broadest context of technological change.

CONTENTS

Student Help Desk

S. N	Purpose	Contact Person	
		Faculty	Instructor
Department Level			
1	Attestations	Dr. B. M. Shrigiri	
2	Online submission of exam form/revaluation form to VTU	Prof. S. B. Awade / Prof. N. M. Ukkali / Prof. M. R. Ingalagi	--
3	Students' Counseling & Discussion with parents (Class Teachers from 3rd A to 7th B)	Prof. Jagadeesh A. Prof. Kushal Ambli Prof. B. M. Doddamani Prof. N. M. Ukkali Prof. R. V. Nyamagoud Prof. M. R. Ingalagi	
4	Department Association Coordinator	Prof. M. M. Shivashimpi/ Prof. M. R. Ingalagi	
5	Students Activities Coordinator	Prof. Jagadeesh A.	
6	Extra-Curricular Activities/ Induction/ Robo Vidya	Prof. T. S. Vandali	
7	Dept.TP Cell Coordinator	Prof. R. V. Nyamagoud	Shri S. R. Nakade
8	I I I coordinator, (INTERNSHIP)	Prof. Chitagopkar Ravi	ShrShri R. B. Kumbar
9	I I I coordinator (INDUSTRY)	Prof. G. A. Naik	
10	Time Table Coordinator	Prof. G. V. Chiniwalar	
11	I. A. Test Coordinator	Prof. A. M. Biradar	Shri S. C. Jotawar
12	Choice of Electives	Prof. S. N. Toppannavar Prof. D. N. Inamdar Prof. T. S. Vandali	---
13	Department Library Coordinator	Prof. Mahantesh I Tanodi	Shri R. M. Hunachyali
14	Department News Letter Coordinator	Prof. M. M. Shivashimpi/ Prof. S. R. Kulkarni/ Prof. M. R. Ingalagi	
15	Department Technical Magazine Coordinator	Prof. M. S. Futane/ Prof. D. N. Inamdar/ Prof. S. R. Kulkarni	
16	Dept. Alumni / Robo Vidya	Prof. Mahesh Hipparagi	
17	Project Coordinators	Prof. Mahantesh I. Tanodi	Shri R. B. Kumbar
18	Dispensary	Dr. Arun G. Bullannavar	Cell No. 9449141549
Institute Level			
01	Student Welfare Convener	Prof. S. B. Akkoli (9480422508)	
02	TP Cell Coordinator	Prof. S. N. Topannavar (9480849332)	
03	Anti Ragging Convener	Prof. M. S. Futane (9480849334)	
04	Anti Squad Convener	Prof. K. M. Akkoli (9739114856)	
05	Anti Sexual Harassment Convener	Smt. Y. S. Patil (9620945478)	
06	Grievance Redressal Convener	Prof. G. A. Naik (9480539283)	
07	Institute News & publicity	Prof. Mahesh Hipparagi (7411507405)	
08	First Year Coordinator	Dr. R. M. Galagali (9945082054)	

Departmental Resources

Department of Mechanical Engineering was established in the year 1996 and is housed in a total area of **2584.5 Sq. Meters**.

Faculty Position

Sl. No.	Category	No. in position	Average experience
1	Teaching faculty	25	16
2	Technical staff	12	13
3	Helper / Peons	05	08

Major Laboratories

S.N.	Name of the laboratory	Area in Sq. Meters	Amount Invested (Rs.)
1	Basic Workshop Laboratory	170	3,91,550=00
2	Fluid Mechanics Machinery Laboratory	172	7,71,941=00
3	Energy Conversion Engg. Laboratory	173	12,37,586=00
4	Machine shop Laboratory	170	13,25,837=00
5	Foundry & Forging Laboratory	179	2,92,984=00
6	Design Laboratory	73	3,64,818=00
7	Heat & Mass Transfer Laboratory	148	5,24,576=00
8	Metallography & Material Testing Laboratory	149	10,73,461=00
9	Mechanical Measurements & Metrology Laboratory	95	5,48,011=00
10	CIM & Automation/CAMA Laboratory	66	36,98,180=00
11	Computer Aided Machine Drawing Laboratory	66	10,04,195=00
12	Computer Aided Engg Drawing Laboratory	66	12,89,363=00
13	Department/Other	--	13,60,486=00
	Total	**1527**	**1,38,82,696=00**

Teaching Faculty Details

S.N.	Faculty Name	Designation	Qualification	Area of specialization	Professional membership	Industry Experience (in years)	Teaching Experience (in years)	Contact Nos.
1	Dr. S. C. Kamate	Principal	Ph. D	Thermal(Cogeneration)	LMISTE	03	25	9480849331
2	Dr. S. A. Alur	Professor	Ph. D	Thermal Power Engg.	LMISTE	---	23	9686856029
3	Dr. B M Shrigiri	HOD/Professor	Ph. D	Thermal Power Engg.	LMISTE	01	19	9741483339
4	Dr. R. M. Galagali	Assoc.Professor	M Tech., Ph.D	PDM, Tribology	-----	02	17	9945082054
5	Prof.S.N.Topannavar	Assoc.Professor	M Tech. (Ph.D)	Thermal Power Engg.	LMISTE	01	17	9482440235
6	Prof. D. N. Inamdar	Asso.Professor	M Tech. (Ph.D)	Tool Engg	LMISTE	08	13	9591208980
7	Prof. K. M. Akkoli	Asso.Professor	M Tech. (Ph.D)	Thermal Power Engg.	LMISTE	1.5	13	9739114856
8	Prof.R.K.Chitgopkar	Asst. Professor	M Tech.	Thermal Power Engg.	LMISTE	1.5	25	9886070475
9	Prof.G. A. Naik	Asst. Professor	M Tech.	Production Management	LMISTE	02	20	9480539283
10	Prof. G. V. Chiniwalar	Asst. Professor	M Tech.	Machine Design	LMISTE	04	13	8762336434
11	Prof.M.S.Futane	Asst. Professor	M Tech.	Computer Integrated Manufacturing	LMISTE	01	11	9164105035
12	Prof. T. S. Vandali	Asst. Professor	M Tech.	Machine Design	LMISTE	8.5	07	9686235904
13	Prof.S. A. Goudadi	Asst. Professor	M Tech.	Design Engineering	LMISTE	--	09	9448876682
14	Sri. S.R. Kulkarni	Asst. Professor	M Tech.	Design Engineering	LMISTE	--	09	8123661692
15	Prof.M.M.Shivashimpi	Asst. Professor	M Tech. (Ph.D)	Thermal Power Engg.	LMISTE	01	07	9742197173
16	Prof.M.A.Hipparagi	Asst. Professor	M Tech. (Ph.D)	Production Technology	LMISTE	02	06	7411507405
17	Prof. A. M. Biradar	Asst. Professor	M Tech.	Machine Design	LMISTE	02	06	9986127703
18	Prof. K. G. Ambli	Asst. Professor	M Tech. (Ph.D)	Product Design and Manufacturing	LMISTE	0.8	05	9164534514
19	Prof. S. B. Awade	Asst. Professor	M Tech.	Machine design	LMISTE		04	9632606108
20	Prof.Mahantesh Tanodi	Asst. Professor	M Tech.	Machine design	LMISTE	--	05	9611998812
21	Prof. N. M. Ukkali	Asst. Professor	M Tech.	Machine Design	LMISTE	--	04	9620152199
22	Prof. M. R. Inagalagi	Asst. Professor	M Tech.	Thermal Power Engg	LMISTE	--	03	9743868503

23	Prof. Jagadeesh A.	Asst. Professor	M Tech.	Thermal Power Engg	LMISTE	--	04	9902847774
24	Prof. R. V. Nyamagoud	Lecturer	M Tech.	Thermal Power Engg	LMISTE	--	03	9964822494
25	Prof. B. M. Dodamani	Asst. Professor	M Tech.	Energy System Engg	LMISTE	02	03	9535447575

S J P N Trust's

Hirasugar Institute of Technology, Nidasoshi.

Inculcating Values, Promoting Prosperity

Approved by AICTE, Recognized by Govt. of Karnataka and Affiliated to VTU, Belagavi.

Mech. Engg.
Course Plan
III B
2018-19

CALENDAR OF EVENTS FOR THE ACADEMIC YEAR 2018-19

Date	Events
01-08-2018	Commencement of III/V Sem Classes
06-08-2018	Commencement of VII Sem Classes
13-08-2018 to 01-09-2018	Commencement of Induction Program for I Semester students
14-08-2018	Fresher's Day (I Sem)
15-08-2018	Independence Day
26-08-2018	Women's Equality Day
05-09-2018	Teachers Day
08-09-2018 & 09-09-2018	Indoor Games
10-09-2018 to 12-09-2018	First Internal Assessment of III/V/VII Sem
14-09-2018 & 15-09-2018	Feed Back-1
15-09-2018	Engineers Day
17-09-2018	Display of First Internal Assessment Marks & Submission of Feedback-1 report to office
22-09-2018	EDP Activities
02-10-2018	Gandhi Jayanti & Swachh Bharat Abhiyan
15-10-2018 to 17-10-2018	First Internal Assessment of I Sem Second Internal Assessment of III/V/VII Sem
22-10-2018 & 23-10-2018	Feed Back-2
25-10-2018	Submission of Feedback-2 Report to Office
25-10-2018	Display of Second Internal Assessment Marks
28-10-2018	Compensatory Working Day of Connecting Holiday 20-10-2018 (Half Day)
01-11-2018	Kannada Rajyotsava
18-11-2018	Compensatory Working Day of Connecting Holiday 07-11-2018
16-11-2018 to 18-11-2018	Second Internal Assessment of I Sem Third Internal Assessment of III/V/VII Sem
22-11-2018 to 24-11-2018	Lab Internal Assessment of III/V/VII Sem
28-11-2018	Display of Third & Final Internal Assessment Marks(III/V/VII Sem)
30-11-2018	Last Working Day of III/V Sem
04-12-2018	Last Working Day of VII Sem
03-12-2018 to 14-12-2018	Practical Exams of III/V Sem
17-12-2018 to 18-01-2019	Theory Exams of III/V Sem
06-12-2018 to 14-12-2018	Practical Exams of VII Sem
17-12-2018 to 18-01-2019	Theory Exams of VII Sem
03-01-2019 to 05-01-2019	Third Internal Assessment of I Sem
09-01-2019 to 11-01-2019	Lab Internal Assessment of I Sem
17-01-2019	Display of Third & Final Internal Assessment Marks (I Sem)
17-01-2019	Last Working Day of I Sem
21-01-2019 to 30-01-2019	Practical Exams of I Sem
04-02-2019 to 18-02-2019	Theory Exams of I Sem

August-2018

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

15- Independance day, 22-Bakrid

September-2018

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

13- Ganesh Chaturthi , 21-Moharam

October-2018

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

2- Gandhi Jayanti, 8- Mahalaya Amavasya, 18- Ayudha Pooja, 19- Vijayadashami, 24- Valmiki Jayanti

November-2018

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

1- Kannada Rajyotsava, 6- Naraka Chaturdashi, 8- Balipadyami, 21- Id-e-Milad, 26- Kanakadasa Jayanthi

December-2018

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

25- Chrismas

January -2019

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

14-Sankranti, 26-Republic Day

Dr. Shilpa Shrigiri
IQAC Co-ordinator

Hirasugar Institute of Technology Nidasoshi Pin-591236 Dt. Belgaum

8/6/18

Dr. S C Kamate
Principal
PRINCIPAL
Hirasugar Institute of Technology
NIDASOSHI-591 236

DEPARTMENT CALENDAR OF EVENTS FOR THE ACADEMIC YEAR 2018-19

Date	Events
01-08-2018	Commencement of III/V Sem Classes
06-08-2018	Commencement of VII Sem Classes
24-08-2018	Welcome function and AIMSS inauguration
31-08-2018	Group Discussion Competition
05-09-2018	Teachers Day
07-09-2018	Industrial Institute Interaction Activity
08-09-2018 To 09-09-2018	Indoor Games
10-09-2018 To 12-09-2018	First Internal Assessment of III/V/VII Sem
15-09-2018	Engineers Day
22-09-2018	EDP Activities
29-09-2018	Industrial Visit (III semester)
02-10-2018	Gandhi Jayanti & Swachh Bharat Abhiyan
06-10-2018	Industrial Visit (V semester)
13-10-2018	Expert talk by Academician
15-10-2018 To 17-10-2018	Second Internal Assessment of III/V/VII Sem
26-10-2018	Hobby Project Competition
27-10-2018	Industrial Visit (V semester)
28-10-2018	Compensatory Working Day of Connecting Holiday 20-10-2018 (Half Day)
01-11-2018	Kannada Rajyotsava
03-11-2018	Industrial Visit (VII semester)
10-11-2018	One Day work shop
16-11-2018 To 18-11-2018	Third Internal Assessment of III/V/VII Sem
22-11-2018 To 24-11-2018	Lab Internal Assessment of III/V/VII Sem
28-11-2018	Display of Third & Final Internal Assessment Marks(III/V/VII Sem)
30-11-2018	Last Working Day of III/V Sem
04-12-2018	Last Working Day of VII Sem
03-12-2018 To 14-12-2018	Practical Exams of III/V Sem
17-12-2018 To 18-01-2019	Theory Exams of III/V Sem
06-12-2018 To 14-12-2018	Practical Exams of VII Sem
17-12-2018 To 18-01-2019	Theory Exams of VII Sem

August-2018

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

15- Independance day, 22-Bakrid

September-2018

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

13- Ganesh Chaturthi , 21-Moharam

October-2018

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

2- Gandhi Jayanti, 8- Mahalaya Amavasya, 18- Ayudha Pooja, 19- Vijayadashami, 24- Valmiki Jayanti

November-2018

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

1- Kannada Rajyotsava, 6- Naraka Chaturdashi, 8-Balipadyami, 21- Id-e-Milad, 26- Kanakadasa Jayanthi

December-2018

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

25- Chrismas

Prof. M.M. Shivashimpi
AIMSS Co-ordinator

Dr. B.M. Shrigiri
HOD

Scheme of Teaching and Examination

3rd Semester "B"

Sl. No.	Subject Code	Title	Teaching Hours per week			Examination				Credits
			Lecture	Tutorial	Practical	Duration (hours)	SSE marks	CIE marks	Total marks	
1	17MAT31	Engineering Mathematics -III	04			03	60	40	100	4
2	17ME32	Materials Science	04			03	60	40	100	4
3	17ME33	Basic Thermodynamics	03	02		03	60	40	100	4
4	17ME34	Mechanics of Materials	03	02		03	60	40	100	4
5	17ME35B	Machine Tools and Operations	04			03	60	40	100	4
6	17ME36B	Mechanical Measurements and Metrology	01		04	03	60	40	100	3
	17MEL37B	Mechanical Measurements and Metrology Laboratory	01		02	03	60	40	100	2
7	17MEL38B	Machine Shop	01		02	03	60	40	100	2
8	17CPH39	Constitution of India, Professional Ethics and Human Rights	01			01	30	20	50	1
		Total	**22/24**	**04**	**08/04**		**510**	**340**	**850**	**28**

VTU Scheme

B.E. Mechanical Engineering
III SEMESTER

Sl. No	Subject Code	Title	Teaching Department	Teaching Hours /Week			Examination				Credits
				Lecture	Tutorial	Practical	Duration (Hours)	SEE Marks	CIE Marks	Total Marks	
1	17MAT31	Engineering Mathematics – III	Maths	04			03	60	40	100	4
2	17ME32	Materials Science	ME	04			03	60	40	100	4
3	17ME33	Basic Thermodynamics	ME	03	02		03	60	40	100	4
4	17ME34	Mechanics of Materials	ME	03	02		03	60	40	100	4
5	17ME35A/ 17ME35B	Metal Casting and Welding	ME	04			03	60	40	100	4
		Machine Tools and Operations	ME								
6	17ME36 A/ 17ME36B	Computer Aided Machine Drawing	ME	01		4	03	60	40	100	3
		Mechanical Measurements and Metrology	ME	03							
7	17MEL37A/ 17MEL37B	Materials Testing Lab/	ME	1		2	03	60	40	100	2
		Mechanical Measurements and Metrology Lab	ME								
8	17MEL38A/ 17MEL38B	Foundry and Forging Lab	ME	1		2	03	60	40	100	2
		Machine Shop/	ME								
9	17KL/CPH39/49	Kannada/Constitution of India, Professional Ethics and Human Rights	Humanities	1			01	30	20	50	1
TOTAL				**22/24**	**04**	**08/04**		**510**	**340**	**850**	**28**

17MAT31- Engineering Mathematics-III

Subject Title	**Engineering Mathematics-III**		
Subject Code	17MAT31	**IA Marks**	40
Number of Lecture Hrs /	04	**Exam Marks**	60
Total Number of Lecture Hrs	50	**Exam Hours**	03
CREDITS – 04			

FACULTY DETAILS:		
Name: i) Prof S. A.Patil ii) Prof S. S. Thabaj	**Designation:** i)Asst. Professor ii) Asst. Professor	**Experience: i) 08** **ii) 08**
No. of times course taught: i) 07 **ii) 07**	**Specialization:** Mathematics	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Mechanical Engineering	II	Engineering Mathematics-II

2.0 Course Objectives

The objectives of this course is to introduce students to the mostly used analytical and numerical methods in the different engineering fields by making them to learn Fourier series, Fourier transforms and Z-transforms, statistical methods, numerical methods to solve algebraic and transcendental equations, vector integration and calculus of variations..

3.0 Course Outcomes

On completion of this course, students are able to:

	Course Outcome	POs
CO1	Know the use of periodic signals and Fourier series to analyze circuits and system communications	1,2,3
CO2	Explain the general linear system theory for continuous-time signals and digital signal processing using the Fourier Transform and z-transform.	1,2,3
CO3	Employ appropriate numerical methods to solve algebraic and transcendental equations	1,2,3
CO4	Apply Green's Theorem, Divergence Theorem and Stokes' theorem in various applications in the field of electro-magnetic and gravitational fields and fluid flow problems.	1,2,3
CO5	Determine the extremals of functional and solve the simple problems of the calculus of variations.	1,2,3
Total Hours of instruction		**50**

4.0 Course Content

MODULES	RBT Levels	No. Of Hours
MODULE-I **Fourier series:** Periodic functions, Dirichlet's condition, Fourier Series of Periodic functions with period 2π and with arbitrary period 2c, Fourier series of even and odd functions, Half range Fourier Series, practical Harmonic analysis-Illustrative examples from engineering field.	**L1 & L2**	**10**
MODULE-II **Fourier Transforms:** Infinite Fourier transform, Fourier Sine and Cosine transforms, inverse Fourier transforms **Z-transform:** Difference equations, basic definition, z-transform-definition, Standard z-transforms, Damping rule, Shifting rule, Initial value and final value theorems (without proof) and problems, Inverse Z-transform. Applications of z-transforms to solve difference equations.	**L1 & L2**	**10**
MODULE-III **Statistical Methods:** Review of measures of central tendency and dispersion. Correlation-Karl Pearson's coefficient of correlation-problems. Regression analysis- lines of regression (without proof) –problems **Curve fitting:** Curve fitting by the method of least squares, Fitting of the curves of the form y= ax+b, $y = ax^2+bx+c$ & $y = ae^{bx}$ **Numerical Methods:** Numerical solution of algebraic and transcendental equations by: Regular-Falsi method and Newton –Raphson method	**L1 & L2**	**10**
MODULE-IV **Finite differences**: Forward and backward differences, Newton's forward and backward interpolation formulae Divided differences-Newton's divided difference formula. Lagrange's interpolation formula and inverse interpolation formula.(all formulae without proof)-Problems. **Numerical integration:** Simpson's $(1/3)^{th}$ and $(3/8)^{th}$ rules, Weddle's rule (without proof) – Problems	**L1 & L2**	**10**
MODULE-V **Vector integration:** Line integrals-definition and problems, surface and volume integrals-definition, Green's theorem in a plane, Stokes and Gauss divergence theorem (without proof) and problems. **Calculus of Variations:** Variation of function and Functional, variational problems, Euler's equation, Geodesics, hanging chain, problems	**L2 & L3**	**10**

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
01	Common to all	Common to all engineering Subjects	Signal and Analysis, Field Theory, Thermodynamics, Fluid Dynamics etc

6.0 Relevance to Real World

SL.No	Real World Mapping
01	Numerical methods are used to solve engineering problems. For examples will be drawn from a variety of engineering problems, including heat transfer, vibrations, dynamics, fluid mechanics, etc.
02	Special functions are used to wave propagation and scattering, fiber optics, heat conduction in solids, and vibration phenomena.
03	In signal processing, sampling is the reduction of a continuous signal to a discrete signal. A common example is the conversion of a sound wave (a continuous signal) to a sequence of samples (a discrete-time signal).

7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	Tutorial	Topic: Sampling Theory

8.0 Books Used and Recommended to Students

Text Books

1) 'B.S. Grewal, Higher Engineering Mathematics, 43rd Edition 2015, Khanna Publishers.
2) E. Kreyszig: Advanced Engineering Mathematics, John Wiley & Sons, 10th Ed., 2015.

Reference Books

1. N P Bali and Manish Goyal, "A text book of Engineering mathematics" , Laxmi publications, 7th Edition, 2010.
2. B.V.Ramana "Higher Engineering M athematics" Tata McGraw-Hill, 2006.
3. H. K Dass and Er. RajnishVerma ,"Higher Engineerig Mathematics", S. Chand Publishing, 1st Edition, 2011.

Additional Study material & e-Books

1. N.P.Bali & Manish.Goyal, A Text book of Engineering Mathematics, 7th edition, Laxmi Publications.

9.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References

1. http://nptel.ac.in/courses.php?disciplineID=111
2. http://wwww.khanacademy.org/
3. http://www.class-central.com/subject/math

10.0 Magazines/Journals Used and Recommended to Students

Sl. No	Magazines/Journals	website
1	+ Plus Magazine	https://plus.maths.org/issue44.
2	Mathematics Magazine	www.mathematicsmagazine.com

11.0 Examination Note

Internal Assessment: 40 Marks

Theoretical aspects as well as relevant sketches should be drawn neatly.

Scheme of Evaluation for Internal Assessment (40 Marks)

(a) Internal Assessment test in the same pattern as that of the main examination (All the three Internal Tests marks considered): **30**Marks.

(b) Assignments: **10** Marks

SCHEME OF EXAMINATION:

Question paper pattern:

Note: - The SEE question paper will be set for 100 marks and the marks will be proportionately reduced to 60.

i) The question paper will have **ten** full questions carrying equal marks.
ii) Each full question consisting of **20** marks.
iii) There will be **two** full questions (with a **maximum** of **three** sub questions) from each module.
iv) Each full question will have sub question covering all the topics under a module.
v) The students will have to answer **five** full questions, selecting **one** full question from each module.

12.0 Course Delivery Plan

Module	Lecture No.	Content of Lecturer	% of Portion
MODULE-1	1	Introduction, Periodic functions, Dirichlet's conditions	20
	2	Fourier series of periodic functions of period 2π	
	3	Fourier series of periodic functions of arbitrary period 2c	
	4	Problems	
	5	Fourier series of even functions	
	6	Fourier series of odd functions	
	7	Problems	
	8	Half range Fourier series	
	9	Practical harmonic analysis	
	10	Problems	
MODULE-2	11	Introduction, Infinite Fourier transform	20
	12	Fourier sine transforms	
	13	Fourier cosine transforms	
	14	Inverse transforms	
	15	z-transform-definition	
	16	Standard z-transforms	
	17	Damping rule, Shifting rule	
	18	Initial value and final value theorems (without proof) and problems	
	19	Inverse z-transform	
	20	Applications of z-transforms to solve difference equations	
MODULE-3	21	Introduction, Statistical Methods: Review of measures of central tendency and dispersion	20
	22	Correlation-Karl Pearson's coefficient of correlation	
	23	Problems	
	24	Regression analysis- lines of regression (without proof) –problems	
	25	Curve fitting by the method of least squares, of the form, form y= ax+b,	
	26	Curve fitting by the method of least squares: $y= a+bx+cx^2$	

	27	Curve fitting by the method of least squares $y = ae^{bx}$	
	28	Numerical solutions: Numerical solution of algebraic and transcendental equations.	
	29	Regular-Falsi method	
	30	Newton –Raphson method	
MODULE-4	31	Introduction, Finite differences: Forward & backward differences	**20**
	32	Newton's forward and backward interpolation formulae	
	33	Problems	
	34	Divided differences- Newton's divided difference formula	
	35	Problems	
	36	Lagrange's interpolation & inverse interpolation formula	
	37	Problems	
	38	Numerical integration: Simpson's one third rule	
	39	Simpson's three eighth rule	
	40	Weddle's rule (without proof) Problems	
MODULE-5	41	Introduction, Line integrals-definition and problems	**20**
	42	Surface and volume integrals-definition,	
	43	Green's theorem in a plane	
	44	Stokes theorem (without proof) problems.	
	45	Gauss divergence theorem (without proof) problems	
	46	Calculus of Variations: Variation of function and Functional, variation problems	
	47	Euler's equation	
	48	Problems	
	49	Geodesics	
	50	Hanging chain, problems	

13.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl.No.	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment 1: University Questions	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 1 of the syllabus	2	Individual Activity.	Book 1, of the reference list. Website of the Reference list
2	Assignment 2: University Questions	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 2 of the syllabus	4	Individual Activity.	Book 1, 2 of the reference list. Website of the Reference list
3	Assignment 3: University Questions	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 3 of the syllabus	6	Individual Activity.	Book 1, 2 of the reference list. Website of the Reference list
4	Assignment 4:	Students study the	Module 4	8	Individual	Book 1, 2 of

	University Questions	Topics and write the Answers. Get practice to solve university questions.	of the syllabus		Activity.	the reference list. Website of the Reference list
5	Assignment 5: University Questions	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 5 of the syllabus	10	Individual Activity.	Book 1, 2 of the reference list. Website of the Reference list

14.0 QUESTION BANK

Module-I: Fourier series:

1) Obtain a Fourier series to represent e^{-ax} from (- , x)
2) Expand f(x) = x sin x, 0 < x < 2, in a Fourier series.
3) For a function f(x) defined by f(x) = |x |, $< x < \pi,$ obtain a Fourier series. Deduce that $\frac{1}{1^2}+\frac{1}{3^2}+\frac{1}{5^2}+\frac{1}{7^2}=\frac{\pi^2}{8}$
4) Find the Fourier series for the function $f(x)=\frac{\pi-x}{2}$ in (0, 2π). Hence deduce that $\frac{\pi}{4}=1-\frac{1}{3}+\frac{1}{5}---$
5) Find the Fourier series to represent f(x) = x+x^2 from x=- π to x= π and deduce that $\frac{1}{1^2}-\frac{1}{2^2}+\frac{1}{3^2}-\frac{1}{4^2}=\frac{\pi^2}{12}$
6) Expand f(x) = e^{-x} as a Fourier series in the interval (–l, l)
7) Obtain Fourier series for the function
$f(x)=\begin{cases}\pi x, & 0\le x\le 1\\ \pi(2-x), & 1\le x\le 2\end{cases}$ and deduce that $\frac{1}{1^2}+\frac{1}{3^2}+\frac{1}{5^2}+\frac{1}{7^2}$-------
8) Develop f(x) in Fourier series in the interval (-2, 2) if $f(x)=\begin{cases}0, & -2<x<0\\ 1, & 0<x<2\end{cases}$

9) Find the half range cosine series for the function f(x) = x^2 in the range 0 ≤ x ≤ l
10) Find the complex form of the Fourier series of the periodic function f(x) = cos ax, in $-\pi < x < \pi$.
11) The following table gives the variation of periodic current over a period

t sec	0	T/6	T/3	T/2	2T/3	5T/6	T
A amp	1.98	1.30	1.05	1.30	-0.88	-0.25	1.98

Show that there is a direct current part of 0.75 amp in the variable current and obtain the amplitude of the first harmonic.

12) Obtain the Fourier series for the function

f(x) = $\begin{cases}1-\frac{2x}{\pi} & -\pi\le x\le 0\\ 1+\frac{2x}{\pi} & 0\le x\le\pi\end{cases}$ Hence deduce that $\frac{\pi^2}{8}=\frac{1}{1^2}+\frac{1}{3^2}+\frac{1}{5}+$ _____

13) Obtain the Fourier expansion of $f(x)=2x-x^2$ in $0\le x\le 2$

14) Obtain the constant term and the coefficient of the first sine and cosine terms in the Fourier expansion of y as given below.

x	0	1	2	3	4	5
y	9	18	24	28	26	20

Module-II: Fourier Transforms:

1) Find the Fourier transform of $f(x) = \begin{cases} 1, & |x| < 1 \\ 0, & |x| < 1 \end{cases}$ Hence evaluate $\int_0^\infty \frac{sinx}{x} dx$

2) Find the Fourier transform of the function $f(x) = \begin{cases} x, & |x| \leq \\ 0, & |x| > a \end{cases}$ Where a is a positive constant?

3) Find the Fourier transform of $cosax^2$

4) Find the Fourier sine transform of e^{-ax}/x

5) Find the Fourier sine and cosine transform of $f(x) = \begin{cases} 1, & 0 \leq x < a \\ 0, & x \geq a \end{cases}$

6) Find the finite Fourier sine and cosine transform of f(x) = 2x, $0 < x < 4$.

7) Find the cosine transform of $f(x) = \frac{1}{1+x^2}$

8) Find the Fourier sine transform of $e^{-|x|}$

9) Find the Fourier transform of $f(x) = \begin{cases} a^{2-}x^2, & |x| < a \\ 0, & |x| > a \end{cases}$ and Evaluate $\int_0^\infty \frac{sinx - xcosx}{x^3} dx$.

10) Find the Fourier sine transform of $f(x) = \frac{e^{-ax}}{x}$, $a > 0$.

11) Find the Fourier cosine transform of $(x) = \begin{cases} x, & 0 < x < 1 \\ 2 - x, & 1 < x < 2 \\ 0, & x > 2 \end{cases}$.

12) Find the Fourier transform of $f(x) = e^{-|x|}$ and Evaluate $\int_0^\infty \frac{xsinmx}{1+x^2} dx$.

13) Find the Fourier transform of $f(x) = e^{-|x|}$ and Evaluate $\int_0^\infty \frac{xsinmx}{1+x^2} dx$.

Z- Transformation:

1. P.T. $z_T(n^2) = \frac{z^2+z}{(z-1)^3}$

2. P.T. $z_T(n^3) = \frac{z^3+4z^2+2}{(z-1)^4}$

3) P.T. $z_T(cos\theta) = \frac{z(z-cos\theta)}{z^2-2zcos\theta+1}$

4) P.T. $z_T(sin\theta) = \frac{(zsin\theta)}{z^2-2zcos\theta+1}$

5) P.T. $z_T(a^n cosn\theta) = \frac{z(z-acos\theta)}{z^2-2azcos\theta+a^2}$

6) Find the Z-transform of $cos\ hn\theta$ & $sinhn\theta$.

7) Find the Z-transform of $(n+1)^2$

8) Using the inversion integral method find the inverse Z-transform of $\frac{3z}{(z-1)(z-2)}$

9) Solve $y_{n+2} + 6y_{n+1} + 9y_n = 2^n$ $y_{n+2} + 6y_{n+1} + 9y_n = 2^n$ with $y_0 = y_n = 0$ using Z-transform

10) Solve the difference equation $y_{n+2} + 2y_{n+1} + y_n = n$ with $y_0 = y_n = 0$ using Z-Transform.

11) Obtain the z-transform of $cos\ n\theta$ and $sin\ n\theta$

12) Find the Inverse z-transform of $\frac{2z^2+3z}{(z+2)(z-4)}$.

13) If $\bar{u}(z) = \frac{2z^2+3z+12}{(z-1)^4}$, find the value of u_0, u_1, u_2, u_3.

14) Solve the difference equation $u_{n+2} + 6u_{n+1} + 9u_n = 2^n$, $u_0 = u_1 = 0$.

Module-III: Statistical Methods:

1) Find the correlation coefficient and regration lines of y and x and x and y for the following data

x	1	2	3	4	5
y	2	5	3	8	7

2) Find the coefficient of correlation for the following data.

x	10	14	18	22	26	30
y	18	12	24	6	30	36

3) Compute the rank correlation coefficient for the following data

x	68	64	75	50	64	80	75	40	55	64
y	62	58	68	45	81	60	68	48	50	70

4) Ten students got the following % of marks in two subjects x and y. Compute their rank correlation coefficient.

Marks in x	78	36	98	25	75	82	90	62	65	39
Marks in y	84	51	91	60	68	62	86	58	53	47

Curve Fitting and Optimization:

1) Find the equation of the best fitting straight line for the data

x	0	1	2	3	4	5
y	9	8	24	28	26	20

2) A simply supported beam carries a concentrated load p at its midpoint corresponding to various values of p the Maximum deflection y is measured & is given below

p	100	120	140	160	180	200
y	0.45	0.55	0.60	0.70	0.80	0.85

Find the law of the form y = a+bp & hence estimate y when p = 150.

3) Fit a second degree parabola of best fit $y = a+bx+cx^2$

x	1.0	1.5	2.0	2.5	3.0	3.5	4.0
y	1.1	1.3	1.6	2.0	2.7	3.4	4.1

4) Fit a second degree parabola $y = ax^2+bx+c$ in the least square sense for the following data

x	0	1	2	3	4
y	1	1.8	1.3	2.5	2.3

5) The voltage v across a capacitor at time t sec is given by the following table

t	0	2	4	6	8
v	150	63	28	12	5.6

Use the method of least square of to fit a curve of the form $v= ae^{kt}$ to this data

6) Find the co-efficient of correlation & regression of lines to the following data.

x	1	2	3	4	5
y	2	5	3	8	7

Numerical Methods

1) Find the real root of the equation $\log_{10} x$ =1.2 by Regula-Falsi method correct to four decimal places.
2) Find by Newton's method, the real root of the equation 3x = cosx +1.
3) Using the Newton's Raphson method, find a root of the following equations correct to the three decimal
4) Places. i) 3sin x – 2x+5 = 0 near 3, ii) x sin x + cos x = 0 which is near x =
5) Find by Newton's method, the root of the equation cos x = x e^x.

6) Use Newton-Raphson method to find a real root of the equation $x - \cos x = 0$

7) By applying Weddle's Rule evaluate $\frac{x}{+x^2}dx$ by considering seven ordinates. Hence find the value of $_e2$

8) Evaluate $\frac{1}{+x}dx,$ by using Simpson 1/3 rd rule, considering seven ordinates. Hence deduce the value of $_e2$.

9) Find the interpolating formula that approximates to the function described by the following table

x	0	1	2	5
y	2	3	12	147

10) Find 'y' when x= 0.26 using appropriate interpolation formula to the following data,

X	0.10	0.15	0.20	0.25	0.30
Y	0.1003	0.1511	0.2027	0.2553	0.3093

11) If y(5)=150 , y(7)=392 , y(11)=1492 , y(13)=2366 ,y(17) = 5202 then find y(9) by using Lagrange's Formula

12) Apply Lagrange's Inverse interpolation formula to find a root of the equation f(x)=0 given that

$$f(30) = -30,\ f(34) = -13,\ f(38) = 3,\ f(42) = 18.$$

13) Use Newton's divided difference formula to find f(4) given

x	0	2	3	6
y	- 4	2	14	158

Module-IV: Finite Differences:

1) The following table gives the distances in nautical miles of the visible horizon for the given heights in feet above the earth's surface

x:height	100	150	200	250	300	350	400
y:distance	10.63	13.03	15.04	16.81	18.42	19.90	21.27

Find the values of y when x=218 feet and 410 feet

2) From the following table, estimate the number of students who obtained marks between 40 & 45

Marks	30-40	40-50	50-60	60-70	70-80
No. of students	31	42	51	35	31

3) In the table below the value of y are consegitive terms of a series of which 23.6 are the 6^{th} term. Find The first & tenth terms of the series

x	3	4	5	6	7	8	9
y	4.8	8.7	14.5	23.6	36.2	52.8	73.9

4) Given the values

x	5	7	11	13	17
f(x)	150	392	1452	2366	5202

Find f(15) and f(19)

6) Use Newton's divided difference formula to find f(x) given the data

x	0	2	3	6
f(x)	-4	2	14	158

7) Given the values

x	5	7	11	13	17
f(x)	150	392	1452	2366	5202

Evaluate f (9) using divided difference formula for unequal intervals.

8) Evaluate $\int_0^1 \frac{dx}{1+x^2}$ by using Simpson's 1/3 rd rule taking four equal strips and hence find the value of π

9) If y(1) =3 , y(3) = 9, y(4) = 30, y(6) =132, Find Lagrange's interpolation formula & hence find y at x=5.

12) Evaluate $\int_0^6 \frac{dx}{1+x^2}$ by using

i) Simpson's 1/3 rd rule , ii) Simpson's 3/8th rule, iii) Weddle's rule .

13) Use Simpson's 1/3 rd rule to find $\int_0^{0.6} e^{-x^2} dx$ by taking seven ordinates.

14) Using Simpson's 3/8th rule , evaluate $\int_0^{0.3} \sqrt{1-8x^3}\, dx$ by taking 7 ordinates.

15) Evaluate $\int_0^{\frac{\pi}{2}} \sqrt{\cos\theta}\, d\theta$ using Weddle's rule

Module-V: Vector Integration:

1) If $\vec{F} = xyi + yzj + zxk$ *evaluate* $\int_c \vec{F}.\vec{dr}$ where c is the curve represented by x=t, y=t^2 , z=t^3 , $-1 \le t \le 1$

2) Find the total work done by the force represented by $3xyi - yj + 2zxk$ in the moving a particle round the circle $x^2 + y^2 = 4$

3) Verify the Greens theorem

$\oint_c (xy + y^2)dx + x^2 dy$ where c is the closed curve of the region bounded by y = x and $y = x^2$

4) Find the area between the parabola $y^2 = 4x$ and $x^2 = 4y$ with the help of Greens theorem in a plane.

5) Verify the Stroke's theorem for the vector function $\vec{F} = 2xyi + (x^2 - y^2)j$ over the circle $x^2 + y^2 = 1$, z = 0

6) Verify the Stroke's theorem for $\vec{F} = yi + zj + xk$ where S is upper half of the sphere $x^2 + y^2 + z^2 = 1$ and C is its boundary.

7) Verify the Divergence theorem for

$\vec{F} = (x^2 - yz)i + (y^2 - zx)j + (z^2 - xy)k$ Taken over the rectangular parallelepiped $0 \le x \le a$, $0 \le y \le b$, $0 \le z \le c$.

8) Verify the Gauss divergence theorem for $\vec{F} = 4xzi - y^2 j + yzk$ over the unit cube.

9) Show that the Geodesics on a plane are straight line.

10) Find the Geodesics on a right circular cylinder of radius a.

11) Find the extremals of the functional $\int_{x_0}^{x_1} \frac{(y')^2}{x^3} dx$

12) Evaluate $\int_c xy\, dx + xy^2 dy$. by Stoke's theorem where c is the square in xy-plane with (1, 0), (-1, 0), (0, 1) & (0, -1)

13) Show that the shortest distance between any two points in a plane is a straight line.

16.0 University Result

Examination	FCD (S+, S, A)	FC (B)	SC (C, D, E)	% Passing
Jan 2018	20	19	68	85.08
Jan 2017	12	16	84	78.36

Prepared by	Checked by		
i) Prof S. A.Patil ii) Prof S. S. Thabaj	Prof. Prof S. L.Patil	HOD	Principal

17ME32- Material Science

Subject Title	**MATERIAL SCIENCE**		
Subject Code	17ME32	**CIE**	40
Number of Lecture Hrs / Week	04	**SEE**	60
Total Number of Lecture Hrs	50	**Exam Hours**	03
		CREDITS – 04	

FACULTY DETAILS:		
Name: Prof. G. A. Naik	**Designation:** Asst. Professor	**Experience:** 23
No. of times course taught:01	**Specialization:** Production Technology	
Name: Prof. K G Ambli	**Designation:** Asst.Professor	**Experience:**05
No. of times course taught:03	**Specialization:** Product Design and Manufacturing	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Mechanical	III / IV	MTO, Metal Casting and Welding

2.0 Course Objectives

This course provides'

1. The foundation for understanding the structure and various modes of failure in materials common in mechanical engineering.
2. Topics are designed to explore the mechanical properties of metals and their alloys, polymers, ceramics, smart materials and composites.
3. The means of modifying such properties, as well as the processing and failure of materials.
4. Concepts of use of materials for various applications are highlighted.

3.0 Course Outcomes

The student shall be able to;

1. Describe the mechanical properties of metals, their alloys and various modes of failure.
2. Understand the microstructures of ferrous and non-ferrous materials to mechanical properties.
3. Explain the processes of heat treatment of various alloys.
4. Understand the properties and potentialities of various materials available and material selection procedures.
5. Know about composite materials and their processing as well as applications.

4.0 Course Content

MODULE 1

Basics, Mechanical Behavior, Failure of Materials

Introduction to Crystal Structure – Coordination number, atomic packing factor, Simple Cubic, BCC, FCC and HCP Structures, Crystal imperfections- point, line & volume imperfections Atomic Diffusion: Phenomenon, Fick's laws of diffusion;Factors affecting diffusion.

Mechanical Behavior:

Stress-strain diagrams showing ductile and brittle behavior of materials, Engineering and true strains, Linear and non-linear elastic behavior 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

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. **(10Hours)**

MODULE 2

Alloys, Steels, Solidification

Concept of formation of alloys: Types of alloys, solid solutions, factors affecting solid solubility (Hume Rothery rules), Binary phase diagrams: Eutectic, and Eutectoid systems, Lever rule, substitutional and interstitial solid solutions, Intermediate phases, Gibbs phase rule Effect of non- equilibrium cooling, Coring and Homogenization 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, Cast metal structures Solidification of Steels and Cast irons. Numerical on lever rule. (**10 Hours)**

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, Recrystallization and Grain growth, Types of annealing, Normalizing, Types of annealing, Normalizing, , Concept of hardenability, Factors affecting it hardenability, surface hardening methods: carburizing, cyaniding, nitriding, flame hardening and induction hardening, Age hardening of aluminum-copper alloys and PH steels. Ferrous materials: Properties, Compositions and uses of Grey cast iron, Malleable iron, SG iron and steel. (**10 Hours)**

MODULE 4

Other Materials, Material Selection

Ceramics: Structure types and properties and applications of ceramics. Mechanical / Electrical behavior and processing of Ceramics.

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

Other materials: Smart materials and Shape Memory alloys, properties and applications. (**10 Hours)**

MODULE 5

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, Processes for production of composites, Characterization of composites, Constitutive relations of composites, Determination of composite properties from component properties, Hybrid composites, Applications of composite materials, Numericals on determining properties of composites. (**10 Hours)**

5.0 Relevance to future subjects

Sl No	Semester	Subject	Topics
01	VIII	Project work	Advanced / Composite Material Testing

6.0 Relevance to Real World

SL.No	Real World Mapping
01	Aerospace Industries, Automobile Industries
02	Research and Development

7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	Lecture	Topic: Shape / Super Memory Alloys, PVD Techniques

8.0 Books Used and Recommended to Students

Text Books
1. Smith, Foundations of Materials Science and Engineering, 4th Edition, McGraw Hill, 2009. 2. William D. Callister, Material science and Engineering and Introduction, Wiley, 2006.
Reference Books
1. V.Raghavan, Materials Science and Engineering, , PHI, 2002 2. Donald R. Askland and Pradeep.P. Phule, The Science and Engineering of Materials, Cengage Learning, 4lh Ed., 2003. 3. George Ellwood Dieter, Mechanical Metallurgy, McGraw-Hill. 4. ASM Handbooks, American Society of Metals.
Additional Study material & e-Books
1. A V Avner. Principle of Metallurgy

9.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References
1) http://nptel.ac.in/courses/113106032/ 2) https://www.youtube.com/channel/UC9sKRSg8Kn5axYdORJUnqFw 3) http://freevideolectures.com/Subject/Metallurgy-and-Material-Science 4) http://www.vssut.ac.in/lecture-notes.php?url=metallurgy-materials-engineering

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	Materials Science and Metallurgy Engineering	http://www.sciepub.com/journal/MSME
2	Journal Of Materials Science & Technology	https://www.elsevier.com/journals/journal-of-materials-science-and-technology/1005-0302?generatepdf=true
3	International Journal of Minerals, Metallurgy and Materials	http://www.sciencedirect.com/journal/international-journal-of-minerals-metallurgy-and-materials
4	International Journal of Minerals, Metallurgy, and Materials	http://www.springer.com/materials/journal/12613

11.0 Examination Note

CIE : 40 Marks
Assignment marks = 10
Internal Assessment Marks = 30

Semester End Examination: 60 Marks
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

12.0 Course Delivery Plan

Module	Lecture No.	Content of Lecturer	% of Portion
1	1	Introduction to Crystal Structure – Coordination number, atomic packing factor, Simple Cubic, BCC, FCC and HCP Structures	20%
	2	Problems on APF, CN.	
	3	Crystal imperfections- point, line & volume imperfections	

	4	Atomic Diffusion: Phenomenon, Fick's laws of diffusion;Factors affecting diffusion.	
	5	Problems on atomic diffusion.	
	6	Stress-strain diagrams showing ductile and brittle behavior of materials, Engineering and true strains Linear and non- linear elastic behavior and properties	
	7	Mechanical properties in plastic range. Stiffness, Yield strength, Offset Yield strength, Ductility, Ultimate Tensile strength, Toughness, Plastic	
	8	Plastic deformation of single crystal by slip and twinning, Mechanisms of strengthening in metals	
	9	Type I, Type II and Type III ,Types of fatigue loading with examples, Mechanism of fatigue, Fatigue properties	
	10	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.	
2	11	Concept of formation of alloys: Types of alloys, solid solutions	20%
	12	Factors affecting solid solubility (Hume Rothery rules), Binary phase diagrams: Eutectic and Eutectoid systems,	
	13	Lever rule, Substitutional and interstitial solid solutions	
	14	Intermediate phases, Gibbs phase rule Effect of non- equilibrium cooling	
	15	Coring and Homogenization	
	16	Iron-Carbon (Cementite) diagram: description of phases	
	17	Effect of common alloying elements in steel, Common alloy steels, Stainless steel, Tool steel, Specifications of steels	
	18	Solidification: Mechanism of solidification, Homogenous nucleation.	
	19	Heterogeneous nucleation, Crystal growth, Cast metal structures	
	20	Solidification of Steels and Cast irons. Numerical on lever rule	
3	21	Heat treating of metals: Time-Temperature-Transformation (TTT) curves, Continuous Cooling	20%
	22	Transformation (CCT) curves, Annealing: Recovery, Recrystallization and Grain growth	
	23	Types of annealing	
	24	Normalizing, Difference between annealing & normalizing	
	25	Concept of hardenability, Factors affecting it hardenability	
	26	Factors affecting it hardenability, surface hardening methods: carburizing	
	27	Nitriding, flame hardening and induction hardening, , SG iron and steel.	
	28	Age hardening of aluminum-copper alloys and PH steels	
	29	Ferrous materials: Properties, Compositions and uses of Grey cast iron, Malleable iron	
	30	Properties, Compositions and uses of S.G. iron & steel	
4	31	Structure types and properties and applications of ceramics.	20%
	32	Mechanical behavior and processing of Ceramics	
	33	Electrical behavior and processing of Ceramics	
	34	Various types of polymers/plastics and their applications	
	35	Mechanical behaviors and processing of plastics, Failure of plastics	
	36	Brief description of other materials such as optical and thermal materials Smart materials – fiber optic materials	
	37	Piezo-electrics, shape memory alloys Shape Memory Alloys – Nitinol	

	38	superelasticity, Biological applications of smart materials - materials used as implants in human Body	
	39	Selection of Materials, Performance of materials in service Residual life assessment	
	40	Use of non-destructive testing, Economics, Environment and Sustainability	
5	41	Composite materials - Definition, classification, types of matrix materials & reinforcements	20%
	42	Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs) and Polymer Matrix Composites (PMCs)	
	43	Particulate-reinforced and fiber- reinforced composites, Fundamentals of production of FRPs	
	44	Fundamentals of production of MMCs	
	45	Characterization of composites, Constitutive relations of composites	
	46	Processes for production of composites	
	47	Determination of composite properties from component properties	
	48	Hybrid composites	
	49	Applications of composite materials in different fields	
	50	Numericals on determining properties of composites	

13.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl.No.	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment 1:	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 1 of the syllabus	2	Individual Activity.	Book 1, 2 of the text book list and 1,2,3 of the Reference list
2	Assignment 2:	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 2 of the syllabus	4	Individual Activity.	Book 1, 2 of the text book list and 1,2,3 of the Reference list
3	Assignment 3:	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 3 of the syllabus	6	Individual Activity.	Book 1, 2 of the text book list and 1,2,3 of the Reference list
4	Assignment 4:	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 4 of the syllabus	8	Individual Activity.	Book 1, 2 of the text book list and 1,2,3 of the Reference list
5	Assignment 5:	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 5 of the syllabus	10	Individual Activity.	Book 1, 2 of the text book list and 1,2,3 of the Reference list

14.0 QUESTION BANK

MODULE 1

1. Define unit cell, space lattice, lattice parameter and coordination number.
2. List the fourteen Bravais space lattices.
3. Explain with neat sketch the following crystal structure I) BCC II)FCC and III)HCP.
4. Define atomic packing factor. Calculate Atomic Packing Factor for BCC structure.
5. Write the sketch of HCP unit cell and determine its APF.
6. If the atomic radius of lead (FCC) is 0.175 nm, calculate its unit cell, volume in meters also calculates APF.

7. Tantalum at 20 deg Celsius is BCC and has Atomic Radius 0.143 nm. Calculate its lattice parameter.
8. Classify crystal imperfections in the order of their geometry.
9. Explain with neat sketch I) Frenkel defect ii) interstitialacy
10. Draw a crystal lattice containing an edge dislocation and show the burgers vector.
11. With the help of neat sketch draw conventional stress-strain diagram for mild steel under uni-axial static tension and explain the behavior of the material till fracture.
12. Draw a neat sketch of stress strain diagram of a) ductile material and brittle material.
13. Define a) elastic strength b) stiffness c) resilience d) toughness e) ductility
14. Compare true stress strain diagram and conventional stress strain diagram for typical ductile material.
15. Draw on the same plot, schematic stress strain curves of mild steel, gray cast iron and copper.
16. Differentiate between ductile material & brittle material.
17. What is plastic deformation & with neat sketches plastic deformation by slip
18. With neat sketches plastic deformation by twinning.
19. Differentiate between slip and twinning deformations in materials.
20. With neat sketches explain stages in a ductile type of fracture.
21. Differentiate between ductile and brittle fractures.
22. Explain with a neat sketch the cup and cone fracture.
23. Derive Griffith's criterion for brittle fracture.
24. Define and explain the phenomenon of fatigue.
25. Explain the mechanism of fatigue crack growth in ductile materials.
26. Draw S-N curve for steel and aluminum.
27. Define creep and explain a typical creep curve.
28. Explain stress relaxation.
29. Explain two important creep mechanisms.
30. Explain briefly temperature effect on creep curve and endurance limit and fatigue strength.

MODULE 2

1. Define an alloy & what are the different types of alloys.
2. What is a solid solution & explain substitutional & interstitial solid solution with neat sketches.
3. State the Hume-Rothery rules.
4. State & explain Gibb's phase rule.
5. What is solid solution and explain the mechanism of solidification.
6. Explain Homogeneous nucleation & Heterogeneous nucleation.
7. Explain with neat sketches cast metal structures.
8. What are the different types of solid solutions, explain it.
9. List the Hume-Rothery rules for the formation of substitutional solid solutions.
10. State and explain Gibb's phase rule and its applicability to metallic systems.
11. Draw a binary eutectic phase diagram between two components, which are partially soluble in each other in the solid state. Label all the phase fields.
12. Considering the example of an isomorphism system and describe the construction of phase diagrams.
13. State and discuss lever rule with an example.
14. Give typical examples for eutectic and eutectoid reactions mentioning for each the temperature and composition at which it occurs. What is an invariant reaction? Write down the following invariant reactions
    a) Eutectic
    b) Peritectic
    c) Eutectoid.
15. A binary alloy of composition 40 percent B, 60 percent A contains two phases namely liquid and solid at particular temperature. The composition of solid phase is 23 percent and that of liquid phase is 68 percent B. estimate the amount of solid and liquid phases in alloy.
16. Describe the construction of phase diagrams by thermal analysis.
17. Draw Fe-C equilibrium diagram and label all the fields, also explain all the invariant reactions in the system.
18. Define austenite, ferrite, cementite, martensite and pearlite.
19. Explain effect of non-equilibrium cooling.
20. Explain the term coring & homogenization.
21. Explain the effect of common alloying elements in steel.
22. Explain the composition, properties & applications of stainless steel, common alloy steels & tool steels.
23. Write a specification of steel.

MODULE 3

1. Explain the steps to construct TTT diagram. Draw a labeled sketch of TTT diagram for an eutectoid steel.
2. What are TTT curves? Explain with neat sketch for eutectoid steels.
3. What are CCT curves and mention its uses.
4. Distinguish between TTT and CCT diagrams. Which is its practical use? Justify.
5. Define the process of heat treatment and classify various heat treatment processes.
6. What is meant by heat treatment? What are its objectives?
7. Explain recrystallization during annealing of metals.
8. Explain annealing and normalizing.
9. Differentiate between annealing and normalizing.
10. Write short notes on cyaniding and high frequency induction surface hardening.
11. Explain the concept of hardenability.
12. Describe Jominy hardenability test and its practical applications.
13. Both pearlite and tempered martensite contain ferrite and cementite, but tempered martensite is stronger and tougher. Explain?
14. What is the purpose of case hardening? Classify the methods of case hardening and describe briefly any two of them.
15. Explain recovery, recrystalization & grain growth in case of annealing.
16. Explain types of annealing.
17. What are the factors affecting the hardenability.
18. Explain austempering & martempering.
19. Explain age hardening & explain it for aluminium-copper alloys & PH steels.
20. Explain the composition, properties & uses for Grey cast iron, malleable cast iron & S.G. iron.

MODULE 4

1. What is a ceramic material**?**
2. What are the different types of ceramics?
3. Explain the structures of the ceramics.
4. Explain the different properties & applications of ceramics.
5. Explain the mechanical behavior & processing of ceramics.
6. Explain the electrical behavior & processing of ceramics.
7. Define a polymer/ plastic.
8. Write down the applications of plastics/ polymers.
9. Explain the mechanical behavior & processing of plastics.
10. Explain the failure of plastics.
11. Briefly explain the thermal & optical materials (smart materials).
12. Briefly explain the term superelasticity.
13. Write down the biological applications of smart materials.
14. What is the use of non-destructive?
15. List advantages & disadvantages of composite materials.
16. Write down the applications of composite materials.

MODULE 5

1. Define composite material
2. Classify composite materials
3. List & explain different types of matrix materials & reinforcements
4. What is a reinforced composite? List & explain its types.
5. Explain FRP with its applications
6. Explain MMC with its applications
7. List advantages & disadvantages of composite materials.
8. What are hybrid composites?
9. Write down the applications of composite materials.

15.0 University Result

Examination	FCD	FC	SC	% Passing
2015-16	03	15	43	96.82

Examination	+S	S	A	B	C	D	E	F	% Passing
2016-17	0	3	13	32	56	20	8	11	92.3
2017-18	0	3	13	32	32	18	15	11	91.08

Prepared by	Checked by		
Prof. K. G. Ambli	Prof. G. A. Naik	HOD	Principal

17ME33- Basic Thermodynamics

Subject Title	BASIC THERMODYNAMICS		
Subject Code	17ME33	**CIA Marks**	40
No of Lecture Hrs + Practical Hrs / Week	4	**SEE Marks**	60
Total No of Lecture + Practical Hrs	50	**Exam Hours**	03
			CREDITS – 04

FACULTY DETAILS:		
Name: Prof. K M Akkoli	**Designation:** Assistant. Professor	**Experience: 15** Years
No. of times course taught: 03	**Specialization:** Thermal Power Engg	
Name: Prof. Jagadeesh A	**Designation:** Assistant. Professor	**Experience: 06** Years
No. of times course taught: 04	**Specialization:** Thermal Power Engg	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
1	Mechanical Engineering	I/II	Elements of Mechanical Engineering
2	Mechanical Engineering	I/II	Engineering Physics

2.0 Course Objectives

- Learn about thermodynamic systems and boundaries
- Study the basic laws of thermodynamics including, conservation of mass, conservation of energy or first law , second law and Zeroth law.
- Understand various forms of energy including heat transfer and work
- Identify various types of properties (e.g., extensive and intensive properties)
- Use tables, equations, and charts, in evaluation of thermodynamic properties
- Apply conservation of mass, first law, and second law in thermodynamic analysis of systems (e.g., turbines, pumps, compressors, heat exchangers, etc.)
- Enhance their problem solving skills in thermal engineering

3.0 Course Outcomes

The student, after successful completion of the course, will be able to

CO	Course Outcome	Cognitive Level	POs
CO1	Explain the fundamental concepts of thermodynamics and energy interactions between the system and surroundings.	A	1,2,6,12
CO2	Interpret and apply first and second law of thermodynamics to flow and non-flow processes	A	1,2,4,6,12
CO3	Estimate the entropy for reversible and irreversible processes and measure Quality, Quantity and Thermodynamic properties of pure substance.	A	1,2,4,6,12
CO4	Analyze the reversible and irreversible processes and derive the thermodynamic relations to evaluate the energy and thermodynamic	A	1,2,4,12
CO5	Evaluate the properties of mixture of ideal and real gases	A	1,2,12
Total Hours of instruction		**50**	

4.0 Course Content

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

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 signconvention.Problems. **10Hours**

MODULE 2

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 applications.

Second Law of Thermodynamics: limitations of first law of thermodynamics Devices converting heat to work; (a) in a thermodynamic cycle, (b) in a mechanical cycle. Thermal reservoir,Direct heat engine; schematic representation and efficiency. Devices converting work to heat in a thermodynamic cycle; reversed heat engine, schematic representation, coefficients of performance. 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. **10Hours**

MODULE 3

Reversibility: Definitions of a reversible process, reversible heat engine, importance and superiority of a reversible heat engine and irreversible processes; factors that make a process irreversible, reversible heat engines. Unresisted expansion, remarks on Carnot's engine, internal and external reversibility, Definition of the thermodynamic temperature scale.Problems

Entropy: Clasius inequality, Statement- proof, Entropy- definition, a property, change of entropy, entropy as a quantitative test for irreversibility, principle of increase in entropy, , calculation of entropy using Tds relations, entropy asacoordinate. **10Hours**

MODULE 4

Availability, Irreversibility and General Thermodynamic relations.Introduction, Availability (Exergy), Unavailable energy (anergy), Relation between increase in unavailable energy and increase in entropy.Maximum work, maximum useful work for a system and control volume, irreversibility, second law efficiency (effectiveness). Gibbs and Helmholtz functions, Maxwell relations, Clapeyron equation, Joule Thomson coefficient, general relations for change in entropy, enthalpy , internal energy and specific heats.

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. **10 Hours**

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, Psychrometric properties, Construction and use of Psychrometric chart. Real gases – Introduction , Air water mixture and related properties, Van-der Waal's Equation of state, Van-der Waal's constants in terms of critical properties, Redlich and Kwong equation of state Beattie-Bridgeman equation , Law of corresponding states, compressibility factor; compressibility chart.Difference between Ideal and real gases. **10 Hours**

5.0 Relevance to future subjects/Area

SL. No	Semester	Subject	Topics / Relevance
01	IV	Applied Thermodynamics	Industry
02	V	Turbo Machines	Power Sector
03	VI	Heat Transfer	Industry

6.0 Relevance to Real World

SL. No	Real World Mapping
01	Automotive Industry
02	Power Sector
03	Aerospace Industray

7.0 Books Used and Recommended to Students

Text Books

- Basic Engineering Thermodynamics, A.Venkatesh, Universities Press, 2008
- Basic and Applied Thermodynamics, P.K.Nag, 2nd Ed., Tata McGraw Hill Pub. 2002

Reference Books

- Thermodynamics, An Engineering Approach, YunusA.Cenegal and Michael A.Boles, Tata McGraw Hill publications,2002
- Engineering Thermodynamics, J.B.Jones and G.A.Hawkins, John Wiley and Sons..
- Fundamentals of Classical Thermodynamics, G.J.VanWylen and R.E.Sonntag, Wiley Eastern.
- An Introduction to Thermodynamcis, Y.V.C.Rao, Wiley Eastern, 1993.
- B.K Venkanna, Swati B. Wadavadagi "Basic Thermodynamics, PHI, New Delhi, 2010

Additional Study material & e-Books

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

8.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References

http://www.nptel.ac.in
http://nptel.ac.in/media/pdf/nptel_2018_booklet.pdf

9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	International Journal of Heat transfer	https://www.journals.elsevier.com/international-journal-of-fluid flow and fluid dynamics/
2	International Journal of Thermodynamics	http://dergipark.ulakbim.gov.tr/eoguijt/

10.0 Examination Note

Internal Assessment (30 Marks)
Questions shall be answered in Internal Assessment books (blue book).Internal assessment book shall be submitted.

Scheme of Evaluation for Internal Assessment (30 Marks)
Internal Assessment test in the same pattern as that of the main examination (Better of the three Tests):30marks.
Assignments (10 Marks)
Assignments for each module are to be submitted and evaluated for 10 marks for each. Average of five modules is to be considered.

SCHEME OF EXAMINATION: Two full questions (with a maximum of four sub questions) of twenty mark each to be set from each module. Each question should cover all the contents of the respective module. Students have to answer five full questions choosing one full question from each module. From each module out of two full questions one full question to be answered and each carries 20 Marks. Five full question to be answered 5x20 = 100 Marks. Later after evaluation total marks are reduced to 60 marks.

11.0 Course Delivery Plan

Module No.	Lecture No.	Content of Lecture	% of Portion
1	1	Fundamental Concepts & Definitions: Thermodynamic definition and scope, Microscopic and Macroscopic approaches. Some practical applications of engineering thermodynamic Systems,	20
	2	Characteristics of system boundary and control surface, examples. Thermodynamic properties; definition and units, intensive , extensive properties,	
	3	specific properties, pressure, specific volume Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic; processes;	
	4	Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium, Zeroth law of thermodynamics,	
	5	Temperature; concepts, scales, international fixed points and measurement of temperature. Constant volume gas thermometer, constant pressure gas thermometer, mercury in glass thermometer	
	6	Work and Heat: Mechanics, definition of work and its limitations. Thermodynamic definition of work; examples, sign convention.	
	7	Displacement work; as a part of a system boundary, as a whole of a system boundary,	
	8	Expressions for displacement work in various processes through p-v diagrams. Shaft work; Electrical work. Other types of work.	
	9	Heat; definition, units and sign convention	
	10	Problems.	
2	11	First Law of Thermodynamics: Joules experiments, equivalence of heat and work. Statement of the First law of thermodynamics	40
	12	extension of the First law to non - cyclic processes,	
	13	energy, energy as a property, modes of energy,	
	14	Extension of the First law to control volume; steady flow energy equation(SFEE), important applications.	
	15	Second Law of Thermodynamics: limitations of first law of thermodynamics	
	16	Devices converting heat to work; (a) in a thermodynamic cycle, (b) in a mechanical cycle.	
	17	Thermal reservoir, Direct heat engine; schematic representation and efficiency. Devices converting work to heat in a thermodynamic cycle; reversed heat engine,	
	18	Schematic representation, coefficients of performance. Kelvin - Planck statement of the Second law of Thermodynamics;	
	19	PMM I and PMM II, Clausius statement of Second law of Thermodynamics, Equivalence of the two statements; Carnot cycle, Carnot principles.	
	20	Problems.	
3	21	Reversibility: Definitions of a reversible process, reversible heat engine, importance and superiority of a reversible heat engine and irreversible processes;	60

	22	Factors that make a process irreversible, reversible heat engines.	
	23	Unresisted expansion, remarks on Carnot's engine,	
	24	Internal and external reversibility, Definition of the thermodynamic temperature scale.	
	25	Problems	
	26	Entropy: Clasius inequality,	
	27	Statement- proof, Entropy- definition, a property, change of entropy,	
	28	entropy as a quantitative test for irreversibility, principle of increase in entropy,	
	29	Calculation of entropy using Tds relations, entropy as a coordinate.	
	30	Problems	
4	31	Availability, Irreversibility and General Thermodynamic relations. Introduction, Availability (Exergy), Unavailable energy (anergy),	**80**
	32	Relation between increase in unavailable energy and increase in entropy.	
	33	Maximum work, maximum useful work for a system and control volume, irreversibility,	
	34	Second law efficiency (effectiveness). Gibbs and Helmholtz functions, Maxwell relations,	
	35	Clapeyron equation, Joule Thomson coefficient, general relations for change in entropy, enthalpy , internal energy and specific heats.	
	36	Pure Substances: P-T and P-V diagrams, triple point and critical points.	
	37	Sub-cooled liquid, saturated liquid, mixture of saturated liquid and vapor, saturated vapor and superheated vapor states of pure substance with water as example.	
	38	Enthalpy of change of phase (Latent heat).Dryness fraction (quality), T-S and H-S diagrams,	
	39	Representation of various processes on these diagrams. Steam tables and its use. Throttling calorimeter, separating and throttling calorimeter.	
	40	Problems	
5	41	Ideal gases: Ideal gas mixtures, Daltons law of partial pressures,	**100**
	42	Amagat's law of additive volumes, evaluation of properties of perfect and ideal gases,	
	43	Air- Water mixtures and related properties,	
	44	Psychrometric properties, Construction and use of Psychrometric chart.	
	45	Real gases – Introduction , Air water mixture and related properties,	
	46	Vander Waal's Equation of state, Van-der Waal's constants in terms of critical properties,	
	47	Redlich and Kwong equation of state Beattie-Bridgeman equation ,	
	48	Law of corresponding states, compressibility factor; compressibility chart.	
	49	Difference between Ideal and real gases.	
	50	Problems	

12.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl.No.	Title	Outcome expected: students able to	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	The seminar will be conducted on uncovered portion of the subject after the II IA and evaluated the activity.					

12.0 QUESTION BANK

Sample Questions	Questions
I	**Module 1** 1. Define the word' Thermodynamics', and differentiate microscopic and macroscopic approaches. 2. Illustrate open and closed systems with examples. 3. Differentiate the intensive and extensive properties. 4. Describe thermodynamic equilibrium. 5. Explain Zeroth law of thermodynamics. 6. Explain the definition of temperature, its scale and measurement. 7. Describe the various thermodynamic temperature scale. 8. Explain International Temperature Scales, Standards 9. Solve numericals on temperature scales 10. Explain System, Boundary and Control volume 11. Define, differentiate and illustrate the heat and work and its sign conventions. 12. Explain the displacement work. 13. Analyze the various thermodynamic processes through PV diagram. 14. Formulate different types of works and describe the conversion to heat and vice versa. 15. Explanation about shaft work and also various work conversion factors 16. Explain the similarities and dissimilarities between work and heat
II	**Module 2** 17. Describe the Joule's experiment and analyze the formulation. 18. Define and explain the first law of thermodynamics. 19. Apply the first law of thermodymics to non-cyclic processes and control volume. 20. Explain the specific heat and enthalpy and their relations. 21. Derive the SFEE and formulate the different applications of SFEE. 22. Explain what are the significance of SFEE 23. Explain PMM I 24. Solve numericals on first law of thermodynamics 25. Define and explain the different definitions of Second Law of Thermodynamics. 26. Explain thermal energy reservoir, sink 27. Explain the two statements on second law and draw similarity between them 28. Explain PMM II and differentiate between PMM-I and PMM-II. 29. Explain and differentiate reversible and irreversible processes and their factors to make different principles. 30. Define heat engine and heat pump. Explain their schematic diagram.
III	**Module 3** 31. Define the "Entropy" and explain the Classius's inequality. 32. Derive the proof of inequality statement and explain its applications. 33. Derive to show that the entropy of universe is always increasing. 34. Solve the examples by using TDS relation. 35. Explain different available and unavailable energy.
IV	**Module 4** 36. Concept of Maxwell Relation 37. Concept of Clausius Clayperson's Equations 38. Derive and explain Ideal gas; equation of state, internal energy and enthalpy as functions of temperature only, universal and particular gas constants, specific heats, perfect and semi-perfect gases. 39. Evaluate heat and work for different qausi-static process. 40. Explain PT and PV diagram of pure substances. 41. Define the dryness fraction and the change of phase. 42. Represent the various processes on T-S and H-S diagram. 43. Use the steam tables. 44. Explain the throttling and separating calorimeter.

V	**Module 5** 45. Derive and explain Vander Waal's Equation and also define compressibility factor. 46. Describe and use of compressibility chart. 47. Derive and Explain Dalton Law of partial pressure 48. Define Amagat's law of additive volumes, evaluation of properties, Analysis of various process.

13.0 University Result

Examination	FCD	FC	SC	% Passing
-	-	-	-	-
-	-	-	-	-

*New Scheme

Prepared by	Checked by		
Prof. Jagadeesh A.	Prof. K. M. Akkoli	HOD	Principal

17ME34- Mechanics of Materials

Subject Title	MECHANICS OF MATERIALS		
Subject Code	17ME34	CIE Marks	40
Number of Lecture Hrs / Week	05 hrs	SEE Marks	60
Total Number of Lecture Hrs	50 (10 Hours per Module)	Exam Hours	03
			CREDITS – 04

FACULTY DETAILS:		
Name: Prof. D.N.Inamdar / Prof. G. V. Chiniwalar.	**Designation:** Asst. Professor	**Experience:** 14/15
No. of times course taught: 06/06	**Specialization:** Tool Design / Machine Design	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Students should have the knowledge of basic subjects	I/II Sem & PUC	Engineering Mechanics, Trigonometry

2.0 Course Objectives

1. Classify the stresses into various categories and define elastic properties of materials and compute stress and strain intensities caused by applied loads in simple and compound sections and temperature changes.
2. Derive the equations for principal stress and maximum in-plane shear stress and calculate their magnitude and direction. Draw Mohr circle for plane stress system and interpret this circle.
3. Determine the shear force, bending moment and draw shear force and bending moment diagrams, describe behavior of beams under lateral loads.
4. Explain the structural behavior of members subjected to torque, Calculate twist and stress induced in shafts subjected to bending and torsion.
5. Understand the concept of stability and derive crippling loads for columns.
6. Understand the concept of strain energy and compute strain energy for applied loads.

3.0 Course Outcomes

Having successfully completed this course, the student will be able to understand construction and working mechanical systems.

CO	Course Outcome	Cognitive Level	POs
C304.1	Understand simple, compound, thermal stresses and strains their relations, Poisson's ratio, Hooke's law, mechanical properties including elastic constants and their relations.	L1,L2	PO1, PO2,PO3,PO4
C304.2	Determine stresses, strains and deformations in bars with varying circular and rectangular cross-sections subjected to normal and temperature loads	L1,L2 & L3	PO1, PO2,PO3,PO4
C304.3	Determine plane stress, principal stress, maximum shear stress and their orientations using analytical method and Mohr's circle	L1,L2 & L3	PO1, PO2,PO3,PO4
C304.4	Determine the dimensions of structural members including beams, bars and rods using Energy methods and also stress distribution in thick and thin cylinders	L1,L2	PO1, PO2,PO3,PO4
C304.5	Draw SFD and BMD for different beams including cantilever beams, simply supported beams and overhanging beams subjected to UDL, UVL, Point loads and couples	L1,L2 & L3	PO1, PO2,PO3,PO4
C304.6	Determine dimensions, bending stress, shear stress and its distribution in beams of circular, rectangular, symmetrical I and T sections subjected to point loads and UDL	L1,L2 & L3	PO1, PO2,PO3,PO4

C304.7	Determine the dimensions of shafts based on torsional strength, rigidity and flexibility and also elastic stability of columns using Rankin's and Euler's theory	L1,L2 & L3	PO1, PO2,PO3,PO4
Total Hours of instruction		**50**	

4.0 Course Content

Module - 1

Stress and Strain: Introduction, Hooke's law, 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, Generalized Hooke's law, Bulk modulus, Relationship between elastic constants. **10 hours**

Module- 2

Analysis of Stress and Strain: Plane 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. **10 hours**

Module- 3

Shear Forces and Bending Moments: 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 and uniformly distributed constant / varying loads.
Stress in Beams: Pure bending, Curvature of a beam, Longitudinal strains in beams, Normal stresses in Beams with rectangular, circular, 'I' and 'T' cross sections, Flexure Formula, Bending Stresses, Deflection of beams : Columns: (Curvature). **10 hours**

Module- 4

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
Columns: Buckling and stability, Critical load, Columns with pinned ends, Columns with other support conditions, Effective length of columns, and Secant formula for columns. **10 hours**

Module- 5

Strain Energy: Castiglione's theorem I and II, Load deformation diagram, Strain energy due to normal stresses, Shear stresses, Modulus of resilience, Strain energy due to bending and torsion.
Theories of Failure: Maximum Principal stress theory, Maximum shear stress theory. **10 hours**

5.0 Relevance to future subjects

Sl. No	Semester	Subject	Topics
01	VII/VIII	Project work	Fundamental concepts
	VII	Advanced Mechanical Vibration	Fundamental concepts of vibrations
02	V/VI	Design of Machine Elements I/II	Design of Keys, Shafts, couplings, Fasteners, Keys and Joints, Rivets, curved beams, springs cylinders.

6.0 Relevance to Real World

SL.No	Real World Mapping
01	Checking for solid body stability & Analysis of Stresses and Strains in machine elements.
02	Design of Boiler, column, Gear, Keys, Beams and Shaft.
03	Determination of Mechanical properties of Engineering materials.

7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	NPTEL Tutorial	Topic: concepts of stress and strain, plane stress system, shear force and bending moment diagram, torsion, columns and theories of failures.

8.0 Books Used and Recommended to Students

Text Books
1. James M Gere, Barry J Goodno, Strength of Materials, Indian Edition, Cengage Learning, 2009.
2. R Subramanian, Strength of Materials, Oxford, 2005.
Reference Books
1. S S Rattan, Strength of Materials, Second Edition, McGraw Hill, 2011.
2. Ferdinand Beer and Russell Johston, Mechanics of materials, Tata McGraw Hill, 2003.
Additional Study material & e-Books
R.C.Hibbler, Sixth Edition, Pearson Education

9.0 Relevant Websites (Reputed Universities and Others) for Notes /Animation / Videos Recommended

Website and Internet Contents References
Introduction to Strength of materials: https://www.youtube.com/watch?v=GkFgysZC4Vc
Solid Mechanics: https://www.youtube.com/watch?v=A1SWKe6ZwVc
Advanced strength of Materials: https://www.youtube.com/watch?v=_2d8YsXwm7M
GATE: https://www.btechguru.com/GATE--mechanical-engineering--strength-of-materials-video-lecture--23--133.html
Video on Torsion of circular shaft: https://www.youtube.com/watch?v=ICDZ5uLGrI4
Video on Bending of beam: https://www.youtube.com/watch?v=asBW0Ojc0bY
Video on deriving bending equation: https://www.youtube.com/watch?v=AvCkrU3KaZw

10.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	Elsevier	https://www.journals.elsevier.com
2	Journal of Gears	http://journals.sagepub.com
3	Journal of Manufacturing Science and Engineering	http://manufacturingscience.asmedigitalcollection.asme.org
4	International Journal of Renewable Energy Research (IJRER)	http://www.ijrer.org
5	Magazines	https://www.asminternational.org/news/magazines

11.0 Examination Note

CONTINUOS INTERNAL EVALUATION: 40 Marks

Scheme of Evaluation for Internal Assessment (30 Marks): Internal Assessment test in the same pattern as that of the main examination (Average of all three tests). Questions shall be answered in internal assessment books (blue book).Internal assessment book shall be submitted.

Scheme of Evaluation for Assignments (10 Marks): Assignment on each module is to be submitted and each module carries 10 marks (Average of all five assignments).Assignment book shall be submitted.

SCHEME OF END SEMESTER EXAMINATION:

Two full questions (with a maximum of four sub questions) of twenty mark each to be set from each module. Each question should cover all the contents of the respective module. Students have to answer five full questions choosing one full question from each module. From each module out of two full questions one full question to be answered and each carries 20 Marks. Five full question to be answered 5x20 = 100 Marks. Later final marks are reduced to 60 marks.

12.0 Course Delivery Plan

Module	Lecture No.	Content of Lecturer	% of Portion
Module-1	1	Introduction to **Mechanics of Materials**	20 %
	2	Definition of stress and strain, Hooke's law	
	3	Calculation of stresses in straight bar	
	4	Calculation of stresses in stepped bar	
	5	Calculation of stresses in Tapered and composite Sections.	
	6	Stresses due to temperature changes	
	7	Shear stress, shear strain, Poisson's ratio and lateral strain	
	8	Generalized hooks law, Elastic constants	
	9	Relationship between elastic constants	
	10	Problems on axially loaded members	
Module-2	11	**Analysis of Stress and Strain**	40 %
	12	Plane stress system	
	13	Components of stresses acting on inclined plane	
	14	Principal stresses and their planes	
	15	Maximum shear stresses, planes and principal angles.	
	16	Problems on stress components calculations	
	17	Mohr's circle method for plane stress analysis	
	18	**Cylinders:** Thin cylinders, Hoop's stress, maximum shear stress	
	19	Circumferential stress and longitudinal stresses	
	20	Thick cylinders and Lami's equation	
Module-3	21	**Shear force and Bending moment diagrams**	60 %
	22	Definition of beam, Types of Beam, Loads and End Conditions.	
	23	Relationship between distributed load, Shear force and Bending moment	
	24	Determination of shear force and Bending moment for Cantilever,Simply supported and	
	25	Single and double overhanging beam subjected to point,UDL, UVL, COUPLE & Bracket load	
	26	**Bending stresses in Beam:** Theory of pure bending	
	27	Curvature of beam, longitudinal strains in the beams	
	28	Normal stresses in beams with rectangular, I, T, C cross-sections.	
	29	Flexural Formula for beams	
	30	Deflection of beams	
Module-4	31	**TORSION:** Torsion of solid circular and hallow shafts	80 %
	32	Torsional Moment of Resistance	
	33	Power transmission of straight and stepped shafts	
	34	Twisting in shaft sections	
	35	Thin tubular and thin walled sections	
	36	**Columns :**Buckling and Stability of columns, critical load	
	37	Analysis of columns with pinned ends and other support conditions	
	38	Effective length of columns	
	39	Secant formula	
	40	Problems on columns	
Module-5	41	**Strain Energy Theory**	100%
	42	Castigliano's theorem I &II	
	43	Load deformation diagram	
	44	Strain energy due to normal stress	
	45	Strain energy due to Shear stress	
	46	Modulus of resistance	
	47	Strain energy due to Bending and Torsion	
	48	**Theories of Failures**	
	49	Maximum principal stress theory	
	50	Maximum shear stress theory	

13.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl.No.	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment 1: University Questions on stress and strain concepts.	Students study the Topics and prepare the multiple choice questioner with answer.	Module-1 of the syllabus	2	Group Activity. Each group should prepare minimum 05 questions expected.	Book 1, 2 of the reference list. Website of the Reference list
2	Assignment 2: University Questions on Analysis of Stress and Strain	Students study the Topics and identify components of stresses &construct Mohr's circle for the given plane stress system.	Module-2 of the syllabus	4	Individual Activity.	Book 1, 2 of the reference list. Website of the Reference list
3	Assignment 3: University Questions on Shear Forces and Bending Moments	Students study the Topics and draw the SFD &BMD for the beam subjected to external load system	Module-3 of the syllabus	6	Individual Activity	Book 1, 2 of the reference list. Website of the Reference list
4	Assignment 4: University Questions on Torsion and Columns	Students study the Topics and derive the torsion equation.	Module-4of the syllabus	8	Individual Activity	Book 1, 2 of the reference list. Website of the Reference list
5	Assignment 4: University Questions on Theories of Failure:	Students study the Topics and explain different theories of failures.	Module-5 of the syllabus	10	Individual Activity	Book 1, 2 of the reference list. Website of the Reference list

14.0 QUESTION BANK

Module1: Stress and Strain:

1.	Define the stress and Strain.
2.	State Hooke's law and define Poisson's ratio.
3.	Draw Stress-Strain diagram for a ductile material.
4.	Define the following: i) Limit of Proportionality ii) Elastic limit iii) Yield point iv) Ultimate stress v) Breaking stress.
5.	Define i) stress ii) Hook's law iii) Elasticity iv) lateral strain.
6.	Draw Stress-Strain diagram for mild steel with salient features.
7.	Draw Stress-Strain diagram for Aluminum.
8.	Define Nominal stress and True stress
9.	Derive an expression for the elongation of a bar subjected to tensile load
10.	Show that the extension produced due to self weight of a bar of uniform cross section fixed at one end suspended vertically is equal to half the extension produced by a load equal to self weight applied at the free end.
11.	Derive an expression for the extension of a rectangular bar which is having continuously varying cross- section
12.	Derive an expression for the extension of a circular bar which is having continuously varying cross section.
13.	Derive an expression for the elongation of a bar of uniform cross section due to its self weight
14.	The observations were made in a tension test of a mild steel i) rod of diameter 10mm ii) length 200mm iii) Extension under a load of 10kN=0.12mm iv) The Maximum load =26kN v) Load beyond which stress-strain curve was not proportional=11KN

vi) Final length at failure =261.5mm, Diameter at failure =5.7mm

Find the limit of proportionality, Young's modulus, percentage elongation of length and percentage reduction of area at failure.

15. A stepped bar having circular sections of diameter 1.5D and D are as shown in ***Figure 1*** 1if ρ and E are the density and Young's modulus of elasticity respectively, find the extension of the bar due toown weight.

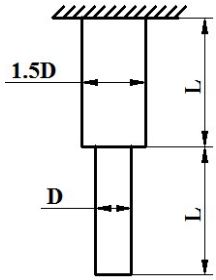
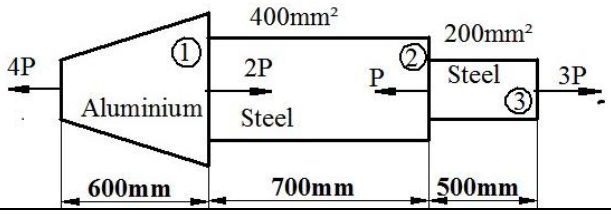


Figure 1

16. A steel wire of 6mm diameter is used for lifting a load 1.5KN at its lower end , the length of the wire being 160 m. Calculate the total elongation of the wire taking E=2x10^5 N/mm^2 and unit weight of steel=78kN/m^3

17. A round bar with stepped portion is subjected to the forces as shown in ***Figure*** *2*. Determine magnitude of force P such that the net deformation in the bar does not exceed 1mm.Young's modulus for steel is 200GPa and that for aluminum is 70GPa. Big end diameter and small end diameter of the tapering bar are 40mm and 12.5mm respectively.



18. A member ABCD is subjected to a pointloads P_1,P_2,P_3 & P_4 as shown in ***Figure 3***. calculate the force P_2 necessary for equibrilium . if P_1 =45KN, P_3 =450KN & P_4= 130KN. Determine stresses in each member also determine the total elongation of the member assuming the E to be 2.1x 0^{5}N/mm^2.

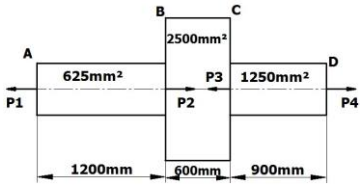


Figure 3

19. For the laboratory tested specimen the following data were obtained,
    i) Diameter of the specimen =25mm
    ii) Length of the specimen =300mm
    iii) Extension under the load of 15KN=0.045mm
    iv) Load at yield point =127.65KN
    v) Maximum load =208.60KN
    vi) Length of the specimen after failure=375mm

    Determine i) Young's modulus ii) Yield point stress iii) Ultimate stress iv) Percentage Elongation v) percentage reduction in area.

20. A stepped bar subjected to an external loading as shown in ***Figure 4***, Calculate the change in the length of the bar. Take E=200Gpa for Steel E=70 GPa for Aluminum and E=100 GPa for Copper (Dec 07/Jan 08)

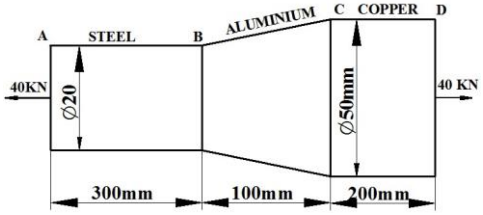


Figure 4

21. A 500 mm long bar has rectangular cross section 20mm x 40mm. This bar is subjected to
    i) 40KN tensile force on 20mm x 40mm faces
    ii) 200KN Compressive forces on20mm x 500 mm faces and
    iii) 300KN tensile force on 40mm x 500mm faces
    Find the change in the volume if $E=2x10^5$ N/mm^2 and $\mu=0.3$.
22. Two copper rods and one steel rod together support a load of 200KN as shown in ***Figure 5***. Find the stress in the rod Take E_s=2 x 105 N/mm^2 and E_c=1 x 105N/mm^2.

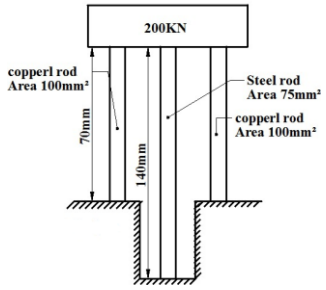


Figure 5

23. A steel bolt of 16mm diameter passes centrally through a copper tube of internal diameter 20mm and external diameter 30mm. The length of the whole assembly is 500mm. after tight fitting of the assembly; the nut is over tightened by quarter of a turn. What are the stresses introduced in bolt and tube, if pitch of the nut is 2mm.Take E=200kN/mm^2.
24. Define the following i) Volumetric strain, ii) Bulk modulus, iii) Poisson's ratio
    iv) Modulus of rigidity v) Modulus of Elasticity iv) Factor of safety.
25. Establish the relationship between Modulus of elasticity and Modulus of rigidity
26. Establish the relationship between Modulus of elasticity and Bulk modulus
27. state the concept of shear stress and shear strain
28. Define volumetric strain. A bar of uniform rectangular section of area A is subjected to an axial load P. show that the volumetric strain is given by $\epsilon_v = \frac{P}{AE}\left(1-\frac{2}{m}\right)$,where E is the young's modulus &1/m is the poisson's ratio.
29. The modulus of rigidity of a material is 0.8 x 10^5N/mm^2. When a 6mmx6mm rod of this material was subjected to an axial pull of 3600N,it was found that the lateral dimensions of the rod changed to 5.9991mmx5.9991mm. Find the poisson's ratio and the modulus of Elasticity.
30. A horizontal rigid bar AB weighing 200KN is hung by three vertical rods, each of 1m length and 500mm^2 cross section as shown in ***Figure 6***. the central rod is of steel and outerrods are copper. If the temperature rise is 40°C, estimate the load carried by each rod and by how much the load will descend.Take E_s=200GN/m^2, E_c=100GN/m^2, $\alpha_s=1.2x10^{-5}$/°C ,$\alpha_c=1.8x10^{-5}$/°C.

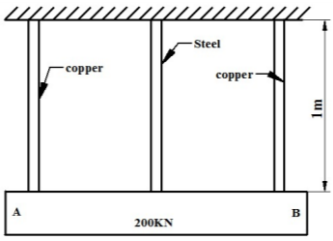


Figure 6

31. A compound bar is made of a central steel plate 60mm wide and 10mm thick to which copper plates 40mm wide and 5mm thick are connected rigidly on each side. The length of the bar at normal temperature is 1 meter. If the temperature is raised by 80°C, determine the stresses in each metal and change in length. Take E_s=200GN/m^2,E_c=100GN/m^2 $\alpha_s=12x10^{-6}$/°C $\alpha_c=17x10^{-6}$/°C
32. A 12 mm diameter steel rod passes centrally through a copper tube 48 mm external diameter and 36mm internal diameter and 32.50 mm long. The tube is closed at each end by 24mm thick steel plates which are secured by nuts .The nuts are tightened until the copper tube is reduced in length by 0.508mm .The assembly is then raised in temperature by 60°C. Calculate the stresses in the copper and steel before and after raising the temperature, assuming the thickness of the plate remain to be unchanged. Take $\alpha_s=1.2x10^{-5}$/°C, $\alpha c=1.75x10^{-5}$/°C, $E_s=2.1x10^5$ N/mm^2,$E_c=1.05x10^5$ N/mm^2
33. A steel tube of 25mm external diameter and 18mm internal diameter encloses a copper rod of 15mm diameter. The ends are rigidly fastened to each other. Calculate the stresses in the the rod and the tube when the temperature is

raised from 15˚ to 200˚C Take α_{st}=11x10^{-6}/˚C, α_{cu}=18x10^{-6}/˚C, E_{st}=200 GPa and E_{cu}=100 GPa

34. A steel bar is placed between two copper bars each having the same area and length as the steel bar at 15˚C. At this stage they are rigidly connected together at both ends. When the temperature is raised to 315˚C, the length of the bars increased by 1.50mm. Determine the original length and the final stresses in the bars. Take E_s=2.1x10^5 N/mm^2, E_c=1x10^5 N/mm^2, α_s=0.000012/˚C, α_c=0.0000175/˚C

35. A 25 mm diameter steel rod passes concentrically through a bronze tube 400mm long,50mm external diameter and 40mm internal diameter. The end of the steel rod are threaded and provided with nuts andwashers which are adjusted initially so that there is no end play at 20°C.assuming that there is no change in the thickness of the washers, find the stress produced in the steel and bronze when one of the nuts is tightened by giving it one-tength of a turn, the pitch of the rhread being 2.5mm. take E for steel=200KN/mm^2 and E for bronze=100KN/mm^2.

36. A compound bar consist of steel, copper and aluminum bars connected in series is held between two supports as shown in ***Figure 7*** .When the temperature of the compound bar is increased by 50˚C, determine stresses induced in each bar. Consider the two cases i) Rigid supports ii) support yield by 0.5mm. Take α_s=12x10^{-6}/˚C α_B=19x10^{-6}/˚C α_{AL}=22x10^{-6}/˚C Es=200 GPa E_B=83 GPa E_{Al}=70 GPa

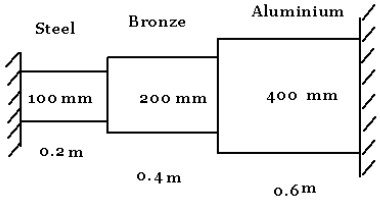


Figure 7

37. A stepped bar shown in ***Figure 8*** is fixed at its two ends rigidly .The bar is free from stresses when its temperature is 30˚C .When the temperature of the bar is increased to 90˚C determine i) Stresses induced in steel and the copper portions and ii) Displacement in the junction at point C .Take α_c=1.8x10^{-5}/˚C, α_s=1.2x10^{-5}/˚C, Ec=100Gpa E_s=200Gpa.

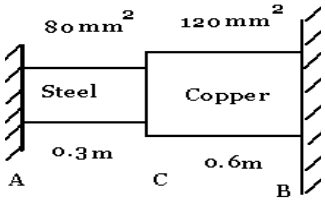


Figure 8

38. A bar of Brass 25mm diameter is enclosed in a steel tube 50mm external diameter. The bar and the tube are both initially 1.5mlong and are rigidly fastened at both ends using 20mm diameter pins .Find the stresses in the two materials when the temperature rises from 30˚C to 100˚C. Take E for Steel =200 kN/mm^2, E for Brass =100KN/mm^2, α for steel =11.6x10^{-6}/˚C, α for brass=18.7x10^{-6}/˚C.

Module 2: Analysis of Stress and Strain and Cylinders:

1. What do you mean by Compound stresses?
2. Define Principal plane and Principal Stress
3. State the sign conventions used in the analysis of stresses
4. What do you understand by maximum shear stress?
5. A rectangular bar is subjected to two direct stresses σ_x and σ_y in two mutually perpendicular directions. Prove that the normal stress(σ_n) & shear stress(τ) on oblique plane which is,

   $\sigma_n = \left(\frac{\sigma_x+\sigma_y}{2}\right) + \left(\frac{\sigma_x-\sigma_y}{2}\right) cos2\theta$ & $\tau = \left(\frac{\sigma_x-\sigma_y}{2}\right)$sin2$\theta$.

6. Explain procedure for constructing of Mohr's circle, for an element acted upon by two tensile stresses and shear stresses.
7. A point in a strained material is subjected to stresses shown in ***Figure 9***. Using Mohr's circle, determine the normal and tangential stresses across oblique plane.check the answer analytically.

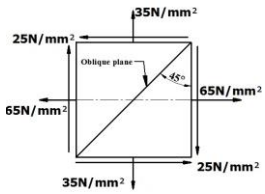


Figure 9

8. The plane element is subjected to stresses as shown in the ***Figure 10***. Determine principal stresses .Maximum shear stresses and their planes. Sketch the plane determined

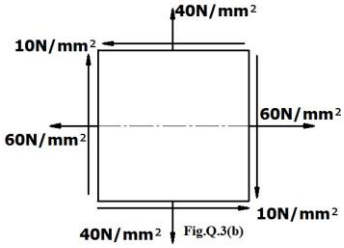


Figure 10

9. The state of the stress in two dimensionally stressed body is shown in ***Figure 11*** .Determine the principal planes, principle stresses ,maximum shear stresses and their planes(June/ July 08)

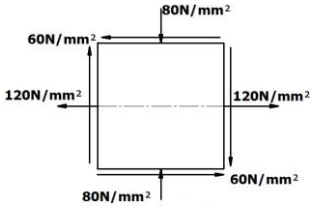


Figure 11

10. Use Mohr's circle, Determine the principal stresses and the planes ,Maximum shear stress and the planes .show the same elements separately

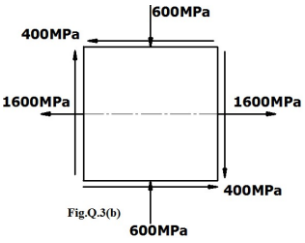


Figure 12

11. A point is strained material is subjected to the stresses as shown in ***Figure 13***. Locate the principal planes and evaluate the principal stresses.

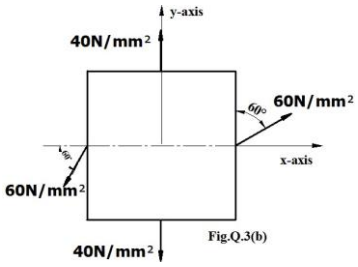


Figure 13

12. The state of stress at a point in strained material is as shown in ***Figure 14***. Determine:
    i) Direction of principle planes
    ii) Magnitude of principle stresses
    iii) Magnitude of the Maximum shear stress and its direction .Indicate all the above by a sketch

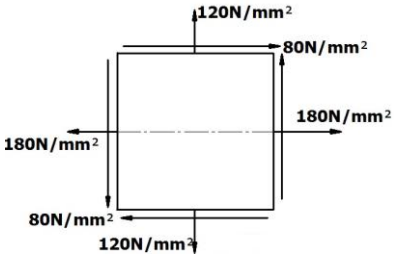


Figure 14

13. The state of stress in two dimensional stressed body is shown in ***Figure*** *15.* Determine principle stresses, principle planes and maximum shear stress .Determine also the normal and tangential stresses on Plane AC .Verify the results

by drawing Mohr's circle.

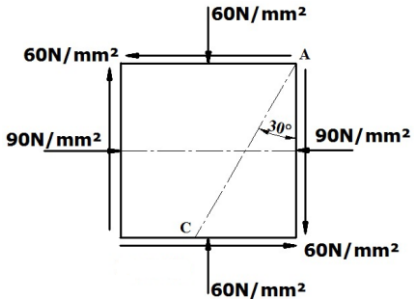


Figure15

14. A point of machine member is subjected to pure shear stress 45Mpa. Determine:
    i) Maximum and minimum stresses induced and orientation of their planes
    ii) ii) stresses on plane whose normal is at an angle of 110˚ with respect to X-axis

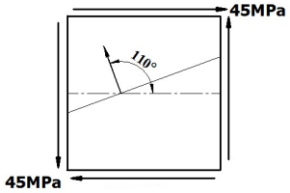


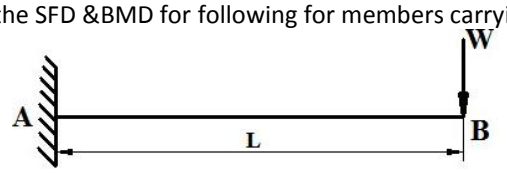
Figure 16

15. What is a thin cylinder and thick cylinder?
16. What do you understand by circumferential and longitudinal stresses?
17. Derive the expressions for the change in the dimensions of a cylinder subjected to internal pressure
18. Derive an expression for strain energy, when member subjected to impact loads.
19. Derive an expression for circumferential stress of a thin cylinder.
20. Define i) strain energy ii) work.
21. Prove that volumetric strain in thin cylinder is given by$(5-4\mu)$, with usual notations.
22. Calculate the i) change in diameter; ii) change in length and iii) change in volume of a thin cylinder shell 1000mm diameter, 10mm thick and 5m long when subjected to internal pressure of 3N/mm^2. Take the value of **E = 2 x 10^5 N/mm^2** and **1/m= 0.3.**
23. A pressure vessel with outer and inner diameters of 400mm and 320mm respectively is subjected to an external pressure of 80MPa. Determine the circumferential stress induced at the inner and outer surfaces. Prove that the longitudinal strain is constant throughout the cylinder.
24. A thick cylinder with internal diameter 80mm and external diameter 120mm is subjected to an external pressure of 40N/mm^2; when the internal pressure is 120N/mm^2, calculate circumferential stress at external and internal surfaces of the cylinder. Plot the variation of circumferential stress and radial pressure on the thickness of the cylinder.
25. A C.I pipe has200mm internal diameter and 50mm metal thickness and carries water under a pressure of 5 N/mm^2. Calculate the maximumnand minmum intensities of circumferential stress and sketch the disribution of circumferentialstress intensities and intensity of radial pressure across the section.
26. A pipe of 400mm internal diameter and 100mm thickness contains a fluid at a pressure of 80N/mm^2.Find the maximum and minimum hoop stresses across the section. Also sketch radial and hoop stresses distribution across the section
27. A thin cylindrical shell 1.2m in diameter and 3m long has a metal wall thickness of 10mm .it is subjected to an internal fluid pressure of 3.2Mpa .Find the circumferential and longitudinal stress in the wall .determine the change in length .diameter the volume of the cylinder .Assume E=210Gpa and μ=0.3
28. A thick cylinder with internal diameter 80mm and External diameter 120mm is subjected to an external pressure of 40Kn/m^2, when the internal pressure is 120KN/m^2 .Calculate the circumferential stress at external and internal surface of the cylinder. Plot the variation of circumferential stress and radial pressure on the thickness of the cylinder
29. A cylindrical tube with closed ends has an internal diameter of 50mmand a wall thickness of 2.50mm.Yhe tube is axially loaded in tension with a load of 10KN and is subjected to an axial torque of 500NM under an internal pressure of 6N/mm^2 .Determine the principle stresses on outer surface of the tube and maximum shear stress.
30. A cylindrical shell 1 meter long ,180mm internal diameter ,thickness of the metal is 8mm is filled with a atmospheric pressure .If an additional 20000mm^3 of the fluid is pumped into the cylinder find the pressure exerted by the fluid on the wall of the cylinder .find also the hoop stress induced .Take E=2x10^{5}N/mm^{2}and 1/m.=0.3.

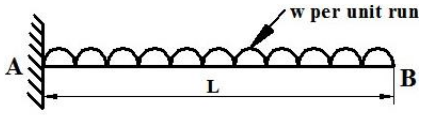
31. A pipe of 200mm internal diameter and 100mm thickness contains a fluid at a pressure of 6N/mm^2.Find the maximum and minimum hoop stresses across the section.
32. Find the thickness of the metal necessary for a steel cylindrical shell of internal diameter 150mm ton with stand an internal pressure of 50N/mm^2.The maximum hoop stress in the section is not to exceed 150N/mm^2.
33. A 1.2 meter long thin cylindrical pressure vessel of 500 mm inner diameter and 14 mm wall thickness undergoes a volume change of 5x10^4 mm^3, when it is subjected to an internal pressure 'p'. Taking E=210GPa and v=0.3 determine the magnitude of P.

Module 3: Shear Forces and Bending Moments: Stress in Beams: Deflection of beams:

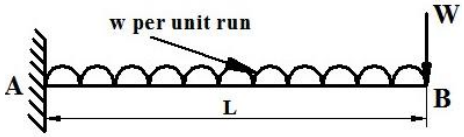
1. What are different types of beams? Explain briefly
2. What are different types of loads
3. Briefly explain different types of beam supports
4. Establish relationship between distriuted load, shear force and bending moment at a cross section of a beam
5. Define i)Shear force ii) Bending moment and iii)Point of contraflecture
6. Draw the SFD &BMD for following for members carrying different loads.



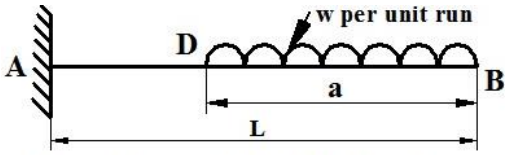
A cantilever of length L carrying a concentraed load w at free end



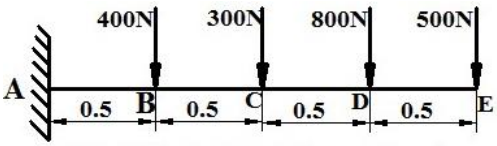
A cantilever of length L carrying a uniformly distributed load w per unit length over the whole length.



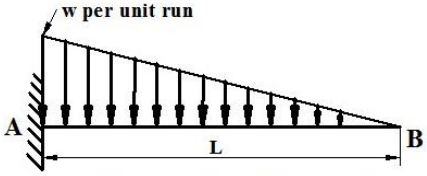
A cantilever of length L carrying a uniformly distributed load w per unit length over the whole length and acomcentrated load W at free end.



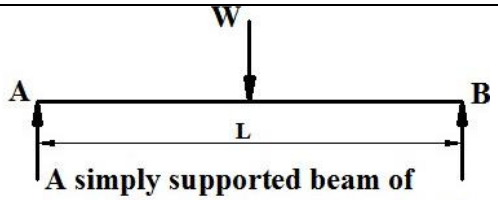
A cantilever of length L carrying a uniformly distributed load w per unit length for a distance 'a' from the free end.



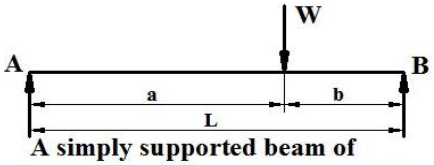
A cantilever carrying several concentraed loads.



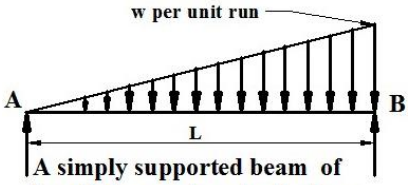
A cantilever of length L carrying a load whose intensity varies uniformly from zero at free end to w per unit run at fixed end.



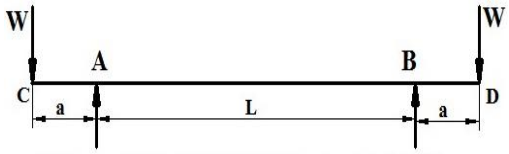
A simply supported beam of length L carrying a concentraed load w at mid span.



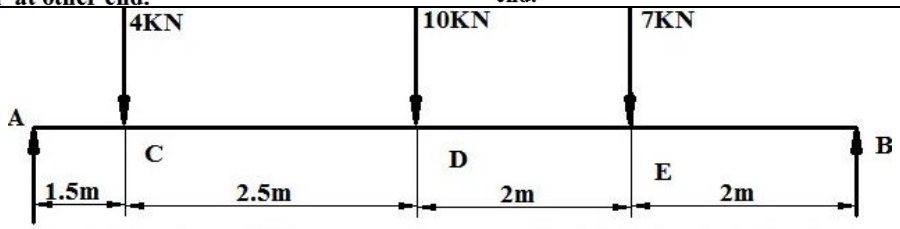
A simply supported beam of length L carrying a concentraed load w placed eccentrically on the span.



A simply supported beam of length L carryinga load whose intensity varies uniformly from zero at one end to w per unit run at other end.

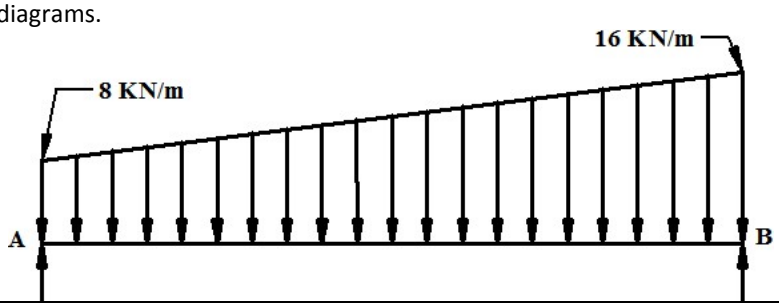


A beam of length (L+2a) has supports 'L' aparts with an overhang 'a' on each side. the beam carries a concentraed load w at each end.



A simply supported beam carrying a number of concentrated loads

7. The intensity of loading on a simply supported beam of length 5m increases uniformly from 8KN/m at one end to 16KN/m at the other end. Find the position and magnitude of the maximum bending moment. Also draw shear and bending moment diagrams.



8. Draw the SFD &BMD for the cantilever beam shown in ***Figure18***

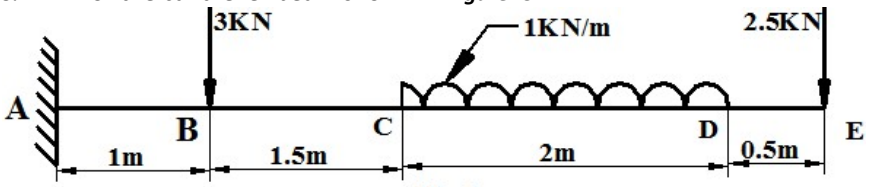


Figure18

9. Draw the beam shown in ***Figure 19***, draw SFD &BMD and mark the values at the salient points.

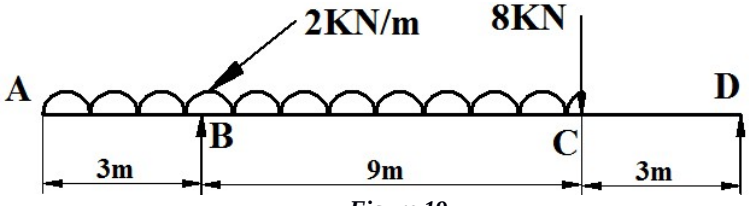


Figure 19

10. Draw the SFD & BMD for the overhanging beam shown in ***Figure 20***. Indicate all significant values including point of contra-flexure.

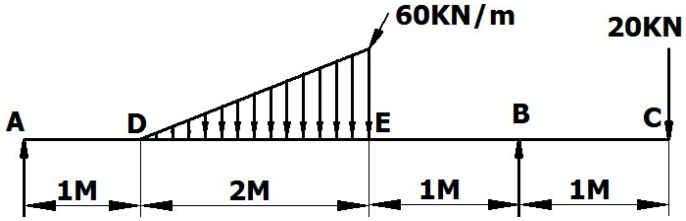


***Figure** 20*

11. Draw the SFD & BMD for the overhanging beam shown in ***Figure 21***. Indicate all significant values including point of contra-flexure.

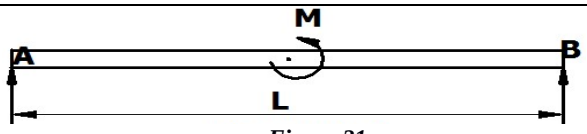


Figure 21

12. A cantilever beam is loaded as shown in ***Figure 22***. Draw the shear force and bending moment diagrams, for the beam.

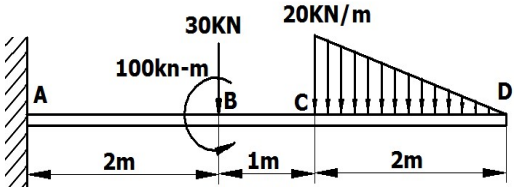


Figure 22

13. Draw shear force and bending moment diagram for overhanging beam as show in ***Figure 23*** and locate the point of contra flexure.

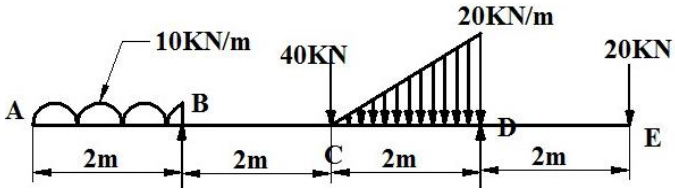


Figure 23

14. Draw shear force and bending moment diagram for the beam loaded as shown in the ***Figure*** 24.

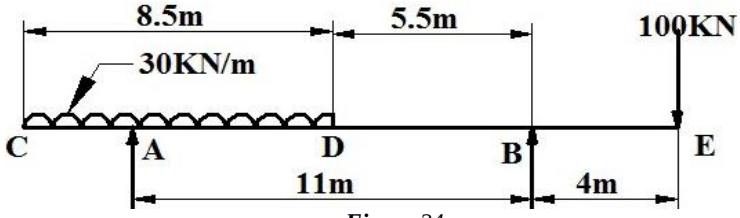


Figure 24

15. For the beams shown in ***Figure 25***, draw shear force and bending moment diagram. Locate point of contra flexure if any

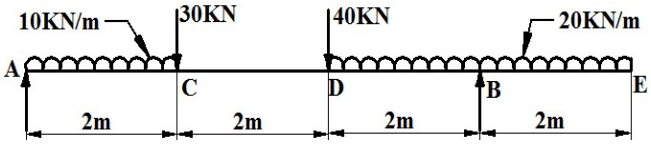


Figure 25

16. For the beam shown in ***Figure 26***. Draw shear force and bending moment diagram and indicating the principle values (June/July 08)

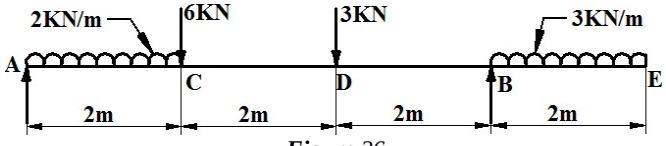


Figure 26

17. Draw shear force and bending moment diagram for the loading factor on the beam as shown in ***Figure 27***. Indicate where the inflection and contra flexure points are located. Also locate maximum bending moment with its magnitude

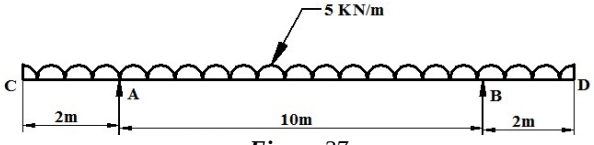


Figure 27

18. For the beam shown in ***Figure 28***. Draw shear force and bending moment diagram

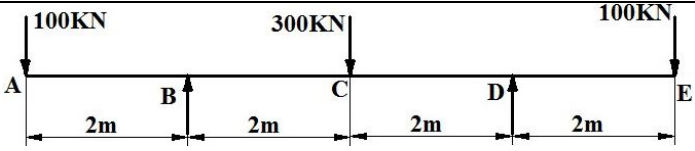


Figure 28

19. For the beam shown in ***Figure 29***. Draw shear force and bending moment diagram

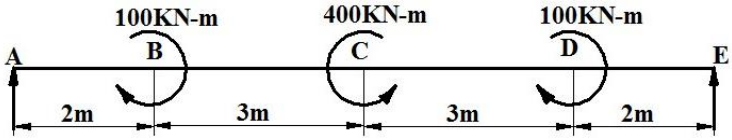


Figure *29*

BENDING STRESS & SHEAR STRESS:

1. What are the assumptions made in simple theory of bending?
2. Prove that $\frac{M}{I} = \frac{\sigma}{Y} = \frac{E}{R}$ with usual notations.
3. Derive an expression for relationship between bending stress and radius of curvature.
4. A beam of an I-section consists of 180mmx15mm flanges and a web of 280mmx 15 mm thicknesses. It is subjected to a shear force of 60KN. Sketch the shear stress distribution along the depth of the section.
5. A I section has the following dimensions, Flanges 200mm x 10mm; web 380mm x 8mm. The maximum shear stress developed in the beam is 20M/mm^2. Find the shear force to which the beam is subjected.
6. A simply supported beam of span 5m has a cross section 150mm x 250mm. if the permissible stress is 10N/mm^2,find i) Maximum intensity of uniformly distributed load it can carry, ii) The maximum concentrated load P applied at 2m from one end it can carry.
7. Prove that the maximum shear stress in a circular section of a beam is 4/3 times the average shear stress.
8. Derive an equation for moment carrying capacity of rectangular and circular sections
9. Explain plain neutral axis and modulus of section as applied to beam.
10. prove that maximum shear stress in a rectangular section of width b and depth d is equal to 1.5 times of its average shear stress
11. At a given position in a beam of uniform I-section is subjected to a bending moment of 100KN-m. Plot the variation of bending stress across the section (refer ***Figure 30***).

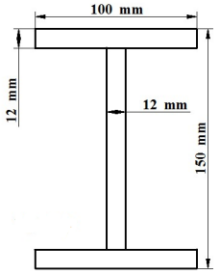


Figure 30

12. A T shaped cross section of a beam as shown in ***Figure 31*** is subjected to a vertical shear force of 100KN. Calculate the shear stress at the neutral axis and at the junction of the web and flange. M I about horizontal neutral axis is 0.000113m^4.

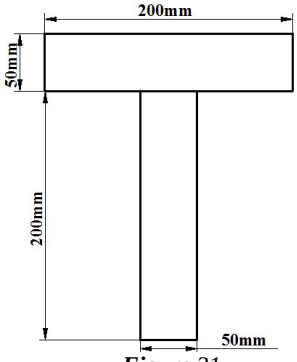


***Figure** 31*

13. Determine the maximum allowable span length "L" for a simple beam as shown in ***Figure 32***. The beam is of

rectangular cross section (140mmx240mm) subjected to a uniformly distributed load q=6.5KN/m and allowable bending stress is 8.2Mpa

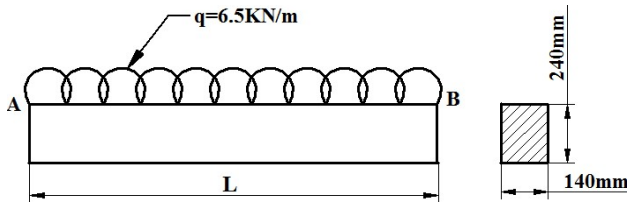


Figure 32

14. Determine the deflection under the loads in the beam as shown in ***Figure 33***. Take flexural rigidity as IE through out

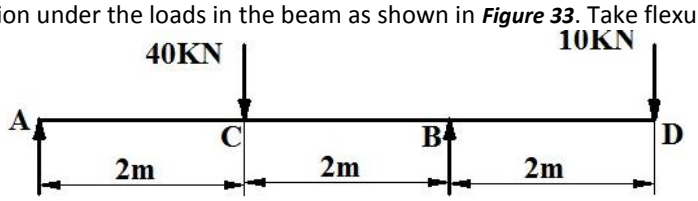


Figure 33

15. An unequal angle section shown in ***Figure 34*** is used as simply supported beam over a span of 2 m and uniformly distributed load of 10 KN/m, inclusive of its own weight. Determine the maximum tensile and compressive stresses in the section

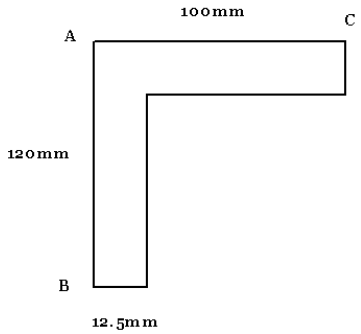


Figure 34

16. A beam of T section has a length of 2.5m and is subjected to a point load as shown in the ***Figure 35***. Calculate compressive bending stress and plot the stress distribution across the cross section of the beam .The maximum tensile stress is limited to 300MPa .Calculate the value of W.

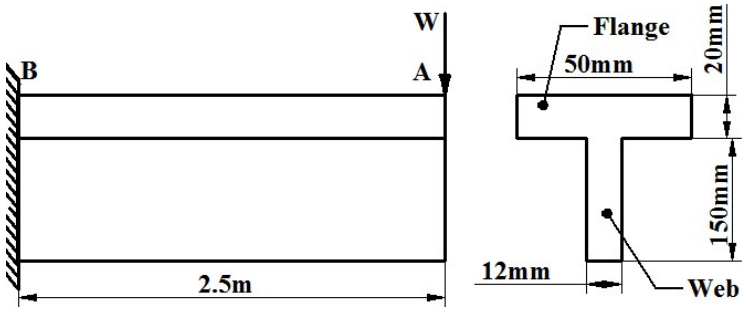


Figure 35

17. A 1 m long cantilever with T section is subjected to a point load 10KN at its free end. The size of the flange is (140 mm x 10mm) and overall depth of the section is 150mm.thickness of web is 10mm.Determine the maximum tensile stress and maximum compressive stress induced in the section and draw the bending stress distribution.

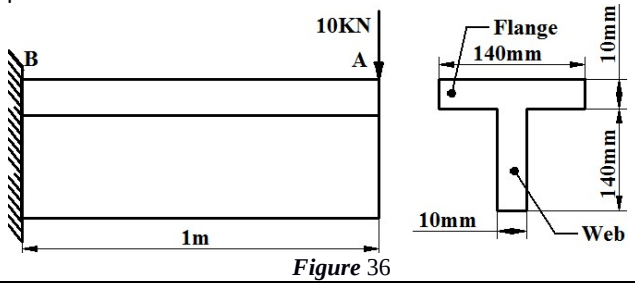


Figure 36

18. A cantilever has an I section with unequal flanges .The upper and lower flanges are (200mmx14mm) and

(100mmx14mm) respectively .The web is (14mmx250mm).The cantilever is subjected to UDL of magnitude 4KN/m over its entire length and a point load W at the free end as shown in the ***Figure 37*** Yield stress for the material of cantilever is 330MPa .Taking the factor of safety as 2. Determine the magnitude of maximum load W that can be applied.

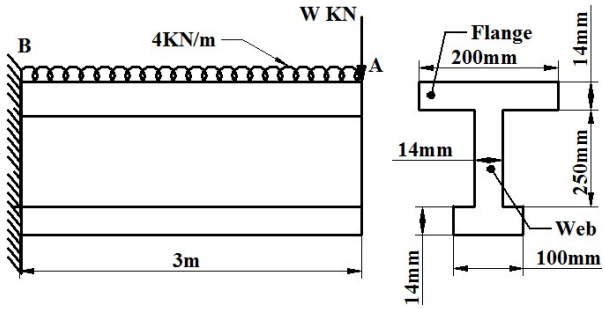


Figure 37

19. When a simply supported beam is subjected to the loads as shown in the ***Figure 38***. The longitudinal strain induced at a point P is found to be $500x10^{-6}$. Determine the magnitude of W. Take E=200GPa.

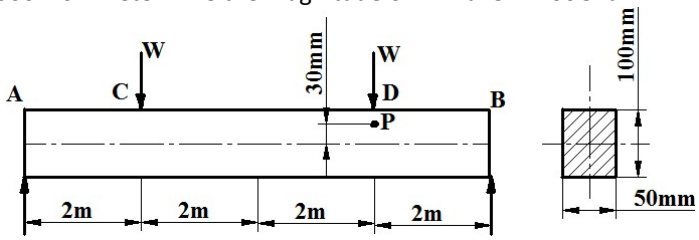


Figure 38

DEFLECTION OF BEAMS:

1. Explain how deflection can be reduced.
2. Derive an expression $EI\frac{d^2y}{dx^2}$= M, with usual notations.
3. For the beam loaded as shown in ***Figure 39***, find the position and magnitude of maximum deflection. Take $E=200x10^6$ N/mm^2 and $I=4.3x10^8$ mm^4.

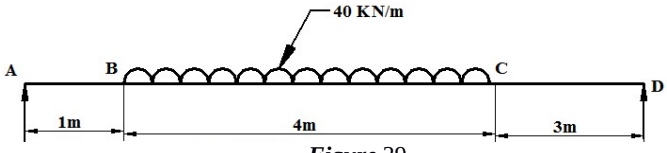


Figure 39

4. Determine the deflection at points C, D, & E in the beam shown in ***Figure 40***. Take $E=200x10^6$ N/mm^2 and $I=60x10^6$ mm^4.

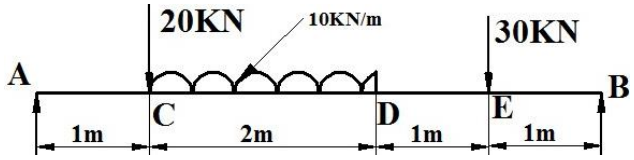


Figure 40

5. A beam of length 5m and of uniform rectangular section is simply supported at its ends. It carries a uniformly distributed load of 9KN/m run over the entire length. Calculate the width and depth of the beam if permissible bending stress is 7N/mm^2 and central deflection is not to exceed 1cm. Take E for beam material = 1×10^4 N/mm^2.
6. Find the expressions for the slope and deflection of a cantilever of length L carrying uniformly distributed load over the whole length.
7. A horizontal girder of steel having uniform section is 14mm long and is simply supported at its ends. It carries concentrated loads of 120KN and 80KN at two points 3m and 4.5m from the two ends respectively. 'I' for the section of the girder is 16×10^8 mm^4 and E= 210KN/mm^2. Calculate the deflections of the girder at points under the two loads. Also find the maximum deflection.
8. A beam of length 6m is simply supported at its ends and carries two points load of 40KN at a distance of 1m and 3m respectively from the left support. By using Macaulay's method , determine (i) Deflection under each load (ii)Maximum deflection (iii)the point at which the maximum deflection occurs .Given E=2x105N/mm^2 and I =$85x10^6$mm^4

9. A steel grinder of 6m length acting as a beam carries a uniformly distributed load w N/m runs throughout its length as shown in ***Figure 41***. If I=30x10^{-6} m^4 and depth 270mm. Calculate i) Magnitude if "w" so that the maximum stress developed in the beam section does not exceed 72 MN/m^2 ii)The slope and the deflection in the beam at s distance of 1.8m from one end .Take E=200GN/m^2(June/July 09)

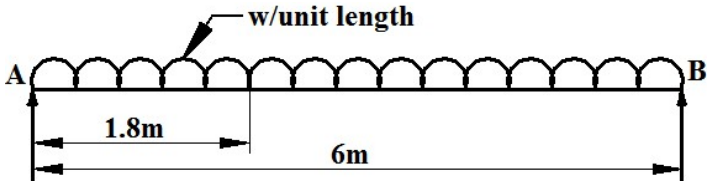


Figure 41

10. A cantilever of square section 200mmx200mm, 2m long just fails in flexure when a load of 12KN is placed at its free end. A beam of same material and having rectangular cross section 150mm wide and 300mm deep is simply supported over a span of 3m.Calculate the minimum central concentrated load required to break the beam(Dec 08/Jan 09)

11. A beam AB of span 6m is simply supported at the ends and is loaded as shown in ***Figure 42***.
    Determine:
    i) deflection at 'C'
    ii) mximum deflection
    iii) Slope at the end A.
    Take N/mm^{2}E=2x105,I=2x107mm^4

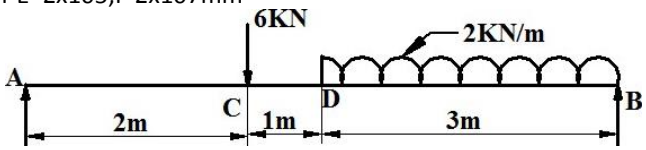


Figure 42

12. A beam of length 4m is simply supported at the ends and carries two concentrated loads of 20 KN and 30KN at a distance 1.5m and 2.5m from left end. Refer below ***Figure 43.*** Find the deflection at mid span. Take E=200GPa and moment of inertia I=3x10^{8}mm^4 of the cross section (June/July 08)

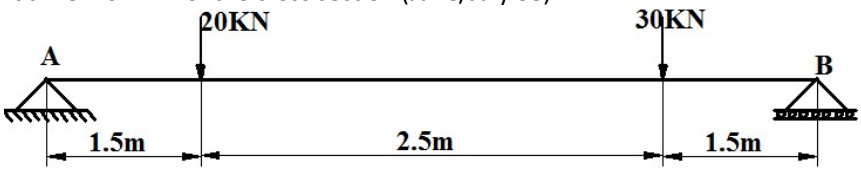


Figure 43

13. A cantilever is subjected to the forces as shown in ***Figure*** *44*. Determine the deflection at the free end. Taking the flexural rigidity for the beam to be 80x10^4 KN-m^2.

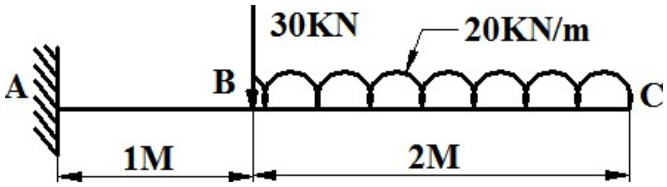


Figure 44

14. A cantilever is subjected to the point load as shown in the ***Figure*** *45*. Determine the deflection at point A and C

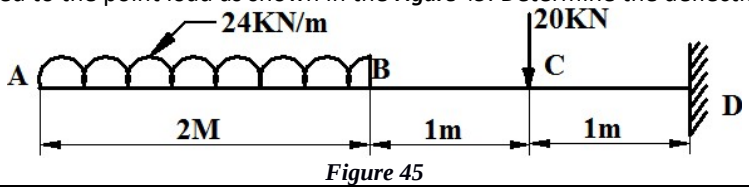


Figure 45

15. A cantilever is subjected to the forces as shown in the ***Figure 46***. Determine deflection and slope at a point which is at a distance of 3m from the free end.

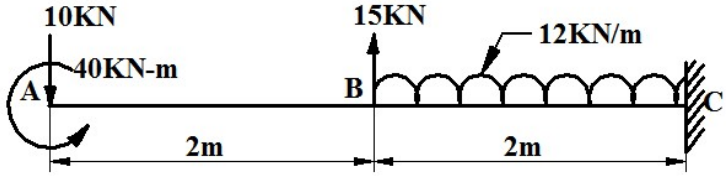


Figure 46

MODULE 4: TORSION&COLUMNS:
16. State the assumptions made in the theory of pure torsion
17. Define Polar Modulus and Torsional rigidity
18. Derive the torsion equation with usual notations. State the assumptions made in the derivation.
19. Define a Column. What are different types of columns?
20. What are the assumptions made in the theory of column?
21. Derive an expression for Euler's buckling load for a long column having one end fixed and other end hinged. State the assumption made in the derivation.
22. Define slenderness ratio and derive Euler's expression for bucking load for column with both ends hinged
23. Define slenderness ratio and derive Euler's expression for buckling load for column with both ends hinged.
24. Derive an expression for the critical load in a column subjected to compressive load, when one is fixed and the other end free.
25. A hollow shaft of diameter ratio 3/8 is required to transmit 588KWatt 110 rpm, the maximum torque being 120%of the mean. Shear stress is not to exceed 63 N/mm^2 and twist in length of 3 m not to exceed 1.4 degrees. Calculate external iameter of shaft which would satishfy theseconditions. Take modulys of rigidity = 84GPa.
26. A hollow shaft having an inside diameter 60% of its outer diameter, is to replace a solid shaft transmitting the same power at the same speed. Calculate the percentage saving in material, if the material to be used is also the same.
27. A hollow C.I. column whose outside diameter is 200mm has a thickness of 20mm. it is 4.5m long and is fixed at both ends. Calculate the safe load by Rankine's formula using a factor of safety of 4. Calculate the slenderness ratio and the ratio of Euler's and Rankine's critical loads. Take f_c = 550N/mm^2, a = 1/1600 in Rankin's formula and E = 9.4 x 10^2.
28. A 1.5m long column has a circular cross section of 50mm diameter .One of ends of a column fixed in direction and position and other end is free .Taker factor of safety as 3,calculate safe loading using i)Rankin's formula , take yield stress=560N/mm2 and a=1/1600 for pinned end ii) Euler's formula ,Young's modulus for C.I=1.2x105 N/mm2
29. A hallow steel shaft 3m long must transmit a torque of 25 KN-m .The total angle of twist in this is not to exceed 2.5degree an allowable shearing stress is 90Mpa .Determine inside and outside diameter of the shaft if G=85Gpa
30. Find the Euler's clipping load a hallow cylindrical steel column of 38mm external diameter and 2.5mm thick .Take length of column as 2.3m and hinged at its both ends. Take E=2.05x105N/mm2.Also determine the crippling loads by Rankin's formula using constants as 335N/mm2 and 1/7500
31. A solid shaft rotating at 500rpm transmits 30KW.Maximum torque is 20% more than mean torque .Allowable shear stress 65MPa and modulus of rigidity 81Gpa ,angle of twist in the shaft should not exceed 1˚ in 1m length .Determine suitable diameter
32. A hollow circular steel shaft has to transmit 60KW at 210rpm such that the maximum shear stress does not exceeds 60MPa.if the ratio of internal to external diameters is equal to ¾ and the value of rigidity is 84GPa, find the dimensions of the shaft and angle of twist in a length of 3m.
33. Find the diameter of the shaft required to transmit 60KW at 150rpm if the maximum torque is 25% of the mean torque for a maximum permissible shear stress of 60MN/m^2. Find also the angle of twist for a length of 4m.Take G=80GPa
34. A 2 meters long hollow cylinder shaft has 80mm outer diameter and 10mm wall thickness. When the tensional load on the shaft is 6KN-m.determine i)Maximum shear stress induced ii) angle of twist .Also draw the distribution of shear stress in the wall of the shaft. Take G as 80GPa (ρ =344)
35. A solid shaft rotating at 500rpm transmits 30KW .The maximum torque is 20% more than the mean torque .Material of shaft has the allowable shear stress 65MPa and modulus of rigidity 81GPa.Angle of twist in the shaft should not exceed 1˚ in 1m length .Determine the diameter of the shaft(ρ=346)
36. Derive an expression for the critical load in a column subjected to compression load, when one end is fixed and the other end free.
37. Derive an expression for the critical load in a column subjected to compression load, when one end is fixed and the other end free.
Module 5: Strain Energy &Theories of Failure.

1.	Derive an expression for strain energy due to shear stresses
2.	Write a note on: (i) Maximum principal stress theory. (ii) Maximum shear stress theory
3.	A hollow circular shaft 2 m long is required to transmit 1000 KW power, when running at a speed of 300 rpm. If the outer diameter of the shaft is 150 mm and inner diameter is 120 mm. find the maximum shear stress and strain energy stored in the shaft.
4.	A solid circular shaft is subjected to a bending moment of 40 KN-m and a torque of 10KN-m.design the diameter of the shaft according to, (i) Maximum principal stress theory. (ii) Maximum shear stress theory. Take μ=0.25, stress at elastic limit=200 N/mm^{2}and FOS=2.
5.	Define the theories of failures and explain Maximum principal stress theory
6.	A rod of circular section is to sustain torsion of 300KN-m & bending moment of 200KN-m. selecting C40 steel(σ_y=353MPa) & FOS = 3. Determine the diameter of rod as per (i) Maximum principal stress theory. (ii) Maximum shear stress theory.
7.	Derive one expression for strain energy stored in an elastic bar when subjected to axial load, torque and bending moment.
8.	The maximum stress produced by a pull in a bar of length 1100 mm is 100 N/mm^2. The area of cross-section and length are shown in fig. calculate the total strain energy stored in the bar if E= 200GPa.
9.	A plate of C45 steel (σ_y=353MPa) is subjected to the following stresses. σ_x= 150 N/mm^2 τ_{xy}= 50 N/mm^2. Find FOS by (i) Maximum principal stress theory. (ii) Maximum shear stress theory
10.	Define strain energy, Resilience, proof resilience and Modulus of resilience.
11.	A cantilever beam of length 'L' carries UDL 'W' per unit length over its entire length. Determine (i) strain energy stored in beam (ii) If 'W'= 10KN/m; L=2m &EI =2X 10^5 KN -mm^2 determine strain energy.

16.0 University Result

Examination	S$^+$ / S/ A	B	C/D/E	F	% Passing
Dec-16/Jan-17(A)	00	1	26	46	**37.00%**
Dec-16/Jan-17(B)	00	02	25	44	**38.00%**
Dec-17/Jan-18(B)	05	12	23	21	**66.66%**

Prepared by	Checked by		
Prof. G. V. Chiniwalar	Prof. D. N. Inamdar	HOD	Principal

17ME35B- Machine Tools and Operations

Subject Title	**MACHINE TOOLS AND OPERATIONS**		
Subject Code	17ME35B	**IA Marks**	40
Number of Lecture Hrs / Week	04	**Exam Marks**	60
Total Number of Lecture Hrs	50	**Exam Hours**	03
		CREDITS – 04	

FACULTY DETAILS:		
Name: Prof. M A Hipparagi	**Designation:** Asst. Professor	**Experience:**10
No. of times course taught:04	**Specialization:** Production Technology	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Mechanical Engineering	I	EME

2.0 Course Objectives

1. To introduce students to different machine tools in order to produce components having different shapes and sizes.
2. To enrich the knowledge pertaining to relative motion and mechanics required for various machine tools.
3. To develop the knowledge on mechanics of machining process and effect of various parameters on economics of machining.

3.0 Course Outcomes

Having successfully completed this course, the student will be able to draw and use modeling software's to generate

	Course Outcome	Cognitive Level	POs	RBT Level
CO1	Classify and demonstrate basic working of all the machine tools	U	PO1,PO2 PO4,PO12	L1
CO2	Explain the different types of relative motions in machining process	U	PO1,PO2 PO4,PO12	L2
CO3	Explain cutting tool materials, tool geometry, surface finish and make use of machining equations for cutting operations.	U	PO1,PO2 PO4,PO12	L2
CO4	Analyze the different mechanics of machining process.	U	PO1,PO2 PO4,PO12	L4
CO5	Appreciate the concept of tool wear, tool life and economics of machining processes with simple numerical	U	PO1,PO2 PO4,PO12	L2
Total Hours of instruction		**50**		

4.0 Course Content

MODULE 1
MACHINE TOOLS
Introduction, Classification, construction and specifications of lathe, drilling machine, milling machine, boring machine, broaching machine, shaping machine, planing machine, grinding machine [**Simple sketches showing major parts of the machines**]**10 hours**

MODULE 2
MACHINING PROCESSES
Introduction, Types of motions in machining, turning and Boring, Shaping, Planing and Slotting, Thread cutting, Drilling and reaming, Milling, Broaching, Gear cutting and Grinding, Machining parameters and related quantities.

[Sketches pertaining to relative motions between tool and work piece only].10 Hours

MODULE 3
CUTTING TOOL MATERIALS, GEOMETRY AND SURFACE FINISH
Introduction, desirable Properties and Characteristics of cutting tool materials, cutting tool geometry, cutting fluids and its applications, surface finish, effect of machining parameters on surface finish.
Machining equations for cutting operations: Turning, Shaping, Planing, slab milling, cylindrical grinding and internal grinding, Numerical Problems.**10 Hours**

MODULE 4
MECHANICS OF MACHINING PROCESSES
Introduction, Chip formation, Orthogonal cutting, Merchants model for orthogonal cutting, Oblique cutting, Mechanics of turning process, Mechanics of drilling process, Mechanics of milling process, Numerical problems.**10 Hours**

MODULE 5
TOOL WEAR, TOOL LIFE: Introduction, tool wear mechanism, tool wear equations, tool life equations, effect of process parameters on tool life, machinability, Numerical problems
ECONOMICS OF MACHNING PROCESSES: Introduction, choice of feed, choice of cutting speed, tool life for minimum cost and minimum production time, machining at maximum efficiency, Numerical problems.**10 Hours**

5.0 Relevance to Future subjects

Sl No	Semester	Subject	Topics
01	VIII	Project work	Machining, Machining time calculations

6.0 Relevance to Real World

SL.No	Real World Mapping
01	Machine tool operations.
02	Cutting tool materials and tool geometry.
03	Machining time calculations.

7.0 Books Used and Recommended to Students

Text Books

1. Fundamentals of metal cutting and Machine Tools, B.L. Juneja, G.S. Sekhon and Nitin Seth, New Age International Publishers 2nd Edition, 2003
2. All about Machine Tools, Heinrich Gerling, New Age International Publishers revised 2nd Edition, 2006

Reference Books

1. Fundamental of Machining and Machine Tools, Geoffrey Boothroyd and Winston A. Knight, CRC Taylor& Francis, Third Edition.
2. Metal cutting principles, Milton C. Shaw, Oxford University Press, Second Edition,2005.

Additional Study material & e-Books

1. "Workshop Technology vol II" .Hazra Choudary

8.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References
https://iitbmechdamp.wordpress.com/me338manufacturingprocessesii/ https://ec.europa.eu/.../sites/.../cross-cutting-kets-roadmap-innovation-fields-manufacturing. https://www.kitaabdeal.com/Manufacturing-Processes---II. https://books.google.co.in/books/about/Manufacturing_Processes_Ii.html?id...

9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	Journal of manufacturing process	https://www.journals.elsevier.com/journal-of-manufacturing-processes/
2	Journal of manufacturing process	http://www.sciencedirect.com/science/journal/15266125
3	Journal of manufacturing science and engineering	https://journaltool.asme.org/home/JournalDescriptions.cfm?JournalID=11
4	**International journal of advanced manufacturing technology**	http://www.springer.com/engineering/production+engineering/journal/170

10.0 Examination Note

Internal Assessment: 40 Marks
Theoretical aspects as well as relevant sketches should be drawn neatly.
Scheme of Evaluation for Internal Assessment (40 Marks)
(c) Internal Assessment test in the same pattern as that of the main examination
(All the three Internal Tests marks considered): **30**Marks.
(d) Assignments: **10** Marks
.

SCHEME OF EXAMINATION:
Question paper pattern:
vi) The question paper will have **ten** full questions carrying equal marks.
vii) Each full question consisting of **20** marks.
viii) There will be **two** full questions (with a **maximum** of **three** sub questions) from each module.
ix) Each full question will have sub question covering all the topics under a module.
x) The students will have to answer **five** full questions, selecting **one** full question from each module.

INSTRUCTION FOR MACHINE TOOLS AND OPERATIONS (17ME35B)
EXAMINATION
1. Draw the neat sketches for relevant theory. The total duration is 3 hours.
2. Draw the flow charts required for some machining processes.

11.0 Course Delivery Plan

Module	Lecture No.	Content of Lecturer	% of Portion
1	51	**MACHINE TOOLS** Introduction , Classification	20%
	52	Construction and specifications of lathe	
	53	Construction and specifications of drilling machine	
	54	Construction and specifications of milling machine	
	55	Construction and specifications of boring machine,	

	56	Construction and specifications of broaching machine	
	57	Construction and specifications of shaping machine	
	58	Construction and specifications of planing machine	
	59	Construction and specifications of grinding machine	
	60	Overview of all the machines	
2	61	**MACHINING PROCESSES** Introduction, Types of motions in machining	40%
	62	Turning and Boring	
	63	Shaping	
	64	Planing and Slotting	
	65	Thread cutting	
	66	Drillingand reaming	
	67	Milling	
	68	Broaching	
	69	Cutting and Grinding	
	70	Gear, Machining parameters and related quantities	
3	71	**CUTTING TOOL MATERIALS, GEOMETRY AND SURFACE FINISH** Introduction	60%
	72	Desirable Properties and Characteristics of cutting tool materials	
	73	Cutting tool geometry	
	74	Cutting fluids and its applications	
	75	Surface finish, effect of machining parameters on surface finish	
	76	**Machining equations for cutting operations:** Turning, Shaping	
	77	Planing, slab milling	
	78	Internal grinding	
	79	Cylindrical grinding	
	80	Numerical Problems	
4	81	**MECHANICS OF MACHINING PROCESSES** Introduction	80%
	82	Chip formation	
	83	Orthogonal cutting,	
	84	Merchants model for orthogonal cutting	
	85	Oblique cutting	
	86	Mechanics of turning process	
	87	Mechanics of drilling process	
	88	Mechanics of milling process	
	89	Numerical problems	
	90	Numerical problems	
5	91	**TOOL WEAR, TOOL LIFE** Introduction	100%
	92	Tool wear mechanism	
	93	Tool wear equations	
	94	Tool life equations	
	95	Effect of process parameters on tool life, machinability	
	96	Numerical problems	
	97	**ECONOMICS OF MACHINING PROCESSES:** introduction	
	98	Choice of feed, choice of cutting speed	
	99	Tool life for minimum cost and minimum production time	
	100	Machining at maximum efficiency, Numerical problems	

12.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl.No.	Title	Outcome expected	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment 1: Study of basic concepts about machine tools	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 1	3	Individual Activity.	Book 1, of the reference list. Website of the Reference list
2	Assignment 2:Can able to Study different machining operations	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 2	6	Individual Activity.	Book 1,2 of the reference list. Website of the Reference list
3	Assignment 3: Understand different cutting tool materials, its geometry	Students study the Topics and write the Answers. Get practice to solve university questions.	Module3	12	Individual Activity.	Book 1, of the reference list. Website of the Reference list
4	Assignment 4: Can able to Study mechanics of machining processes	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 1	15	Individual Activity.	Book 1,2 of the reference list. Website of the Reference list
5	Assignment 5: Basics of Economics of Machining Process	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 1	18	Individual Activity.	Book 1,2, of the reference list. Website of the Reference list

13.0 QUESTION BANK

QUESTION BANK:

MODULE 1

INTRODUCTION TO MACHINE TOOLS

1.Explain the construction and specifications of lathe
2. Explain the construction and specifications of drilling machine
3. Explain the construction and specifications of milling machine
4. Explain the construction and specifications of boring machine,
5. Explain the construction and specifications of broaching machine
6. Explain the construction and specifications of shaping machine
7. Explain the construction and specifications of planing machine
8. Explain the construction and specifications of grinding machine

MODULE 2

MACCHINING PROCESS

1.Explain Planing and Slotting with neat sketch
2.Explain Thread cutting with neat sketch
3. Explain Drilling and reaming with neat sketch
4.Explain Milling with neat sketch
5.Explain Broaching with neat sketch
6.Explain cutting and Grinding with neat sketch
7.Explain Gear, Machining parameters and related quantities

MODULE 3

CUTTING TOOL MATERIALS,GEOMETRY AND SURFACE FINISH

1.What are the desirable Properties and Characteristics of cutting tool materials
2.Explain the cutting tool geometry with neat sketch
3.Explain the cutting fluids and its applications
4.Briefly explain the surface finish, effect of machining parameters on surface finish
5.Derive the machining equation for Turning, Shaping
6. Derive the machining equation Planing, slab milling
7. Derive the machining equation Internal grinding
8. Derive the machining equation cylindrical grinding
9.A cast iron plate measuring 300x100x40mm is to be rough shaped along its wider face.calculate the machining time taking approach=25mm, over travel =25mm, cutting speed =12m/min, return speed =20m/min, allowance on either side of the plate width=5mm and feed per cycle=1mm.

MODULE 4

MECHANICS OF MACHINING PROCESS

1.Explain with neat sketch Chip formation mechnism
2.Expain in brief Orthogonal cutting & Oblique cutting
3.Explain the Merchants model for orthogonal cutting
4.Explain the Mechanics of turning process
5.Explain the Mechanics of drilling process
6.Explain the Mechanics of milling process
7. In an orthogonal cutting, the following data were observed : depth of cut=0.25mm,horizontal force=1135N,thrust force=110N,rake angle=200,width of cut=4mm,cutting velocity=30m/min,chip thickness ratio=0.47.Determine friction angle, shear plane angle, resultant cutting force & the power required

MODULE 5

TOOL LIFE, TOOL WEAR

ECONOMICS OF MACHINING PROCESS

1.Explain the tool wear mechanism
2.Explain tool wear equations for the cutting tool
3.Explain the tool life equations
4.Briefly describe the effect of process parameters on tool life, machinability
5.Explain the importance of choice of feed, choice of cutting speed
6.Describe the tool life for minimum cost and minimum production time
7.machining at maximum efficiency,
8. A certain tool during rough turning gave a tool life of 1 hr at a cutting speed of 30 m/min. what will be the life of the tool when it is used at the same cutting speed for finish turning. Take n=0.125 for rough cut, and n=0.1 for finish cut.

15.0 University Result

Examination	FCD (S+, S, A)	FC (B)	SC (C, D, E)	% Passing
Jan 2018	19	33	10	100
July 2017	21	37	14	100

Prepared by	Checked by		
Prof.M A Hipparagi	Prof.M A Hipparagi	HOD	Principal

17ME36B- Mechanical Measurements and Metrology

Subject Title	MECHANICAL MEASUREMENTS AND METROLOGY		
Subject Code	17ME36B	CIE Marks	40
Number of Lecture Hrs / Week	03	Exam Marks	60
Total Number of Lecture Hrs	40	Exam Hours	03
			CREDITS – 03

FACULTY DETAILS:		
Name: Prof. B M Dodamani	Designation: AP	Experience:06 years
No. of times course taught:06	Specialization: Energy systems Engineering	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Mechanical Engineering	I	Mechanical Engineering Science
02	Mechanical Engineering	III	Mechanical measurements and Metrology

2.0 Course Objectives

Students are expected to –

- Understand metrology, its advancements & measuring instruments,
- Acquire knowledge on different standards of length, calibration of End Bars, linear and angular measurements, Screw thread and gear measurement & comparators.
- Equip with knowledge of limits, fits, tolerances and gauging.
- Acquire knowledge of measurement systems and methods with emphasis on different transducers, intermediate modifying and terminating devices.
- Understand the measurement of Force, Torque, Pressure, Temperature and Strain.

3.0 Course Outcomes

The student, after successful completion of the course, will be able to

CO	Description	Cognitive Level	POs
CO208.1	Understand the objectives of metrology and methods of measurement, selection of measuring instruments, standards of measurement and calibration of end bars.	L1,L4	PO1, PO6
CO208.2	Explain tolerance, limits of size, fits, geometric and position tolerances, gauges and their design and different comparators with their functional requirement	L1,L3,L4	PO1, PO6
CO208.3	Describe measurement of major, minor, effective diameter, pitch, angle of screw threads and use of Laser in Metrology	L2,L3	PO1, PO6
CO208.4	Describe different Measurement systems and basic concepts of measurement methods with different intermediate and terminating devices	L2,L3	PO1, PO6
CO208.5	Describe functioning requirement of force, torque, pressure, strain and temperature measuring devices.	L1,L2	PO1, PO6
Total Hours of Instructions		**40**	

4.0 Course Content

MODULE -1

Introduction to Metrology: Definition, objectives and concept of metrology, Need of inspection, Principles, process, methods of measurement, Classification and selection of measuring instruments and systems. Accuracy, precision and errors in measurement.

System of measurement, Material Standard, Wavelength Standards, Subdivision of standards, Line and End standards, Classification of standards and Traceability, calibration of End bars(Numericals), standardization.

Linear Measurement and angular measurements:

Slip gauges- Indian standards on slip gauge, method of selection of slip gauge, stack of slip gauge, adjustable slip gauge, wringing of slip gauge, care of slip gauge, slip gauge accessories, problems on building of slip gauges (M87, M112).

Measurement of angles- sine bar, sine center, angle gauges, optical instruments for angular measurements, Auto collimator-applications for measuring straightness and squareness.

MODULE -2

System of Limits, Fits, Tolerance and Gauging:

Definition of tolerance, Specification in assembly, Principle of interchangeability and selective assembly, limits of size, Indian standards, concept of limits of size and tolerances, definition of fits, hole basis system, shaft basis system, types of fits and their designation (IS 919-1963), geometric tolerance, position-tolerances.

Classification of gauges, brief concept of design of gauges (Taylor's principles), Wear allowance on gauges, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials.

Comparators:

Functional requirements, classification, mechanical- Johnson Mikrokator, sigma comparators, dial indicator, electrical- principles, , LVDT, Pneumatic- back pressure gauges, solex comparators and 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,Tool maker's microscope.

Gear tooth terminology, tooth thickness measurement using constant chord method, addendum comparator method and base tangent method, measurement of pitch, concentricity, run out, and involute profile. Gear roll tester for composite error.

Advances in metrology:

Basic concepts of lasers, advantages of lasers, laser interferometers, types, applications. Basic concepts of Coordinate Measuring Machines-constructional features, applications.

MODULE -4

Measurement systems and basic concepts of measurement methods:

Definition, significance of measurement, generalized measurement system, definitions and concept of accuracy, precision, calibration, threshold, sensitivity, hysteresis, repeatability, linearity, loading effect, system response-time delay. Errors in measurement, classification of errors.Transducers, transfer efficiency, primary and secondary transducers, electrical, mechanical, electronic transducers, advantages of each type 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

Force, Torque and Pressure Measurement:

Direct methods and indirect method, force measuring inst. Torque measuring inst., Types of dynamometers, Absorption dynamometer, Prony brake and rope brake dynamometer, and power measuring instruments.Pressure measurement, principle, 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, Wheatstone bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors.

Resistance thermometers, thermocouple, law of thermocouple, materials used for construction, pyrometer, optical pyrometer.

5.0 Relevance to future subjects

SL. No	Semester	Subject	Topics / Relevance
01	III / IV	Mechanical measurements and Metrology Lab	Provides basics of measurement process and different measurement systems and measuring instruments to be used in MMM Lab
02	VIII	Project work	Generation of components for project

6.0 Relevance to Real World

SL.No	Real World Mapping
01	Measuring a physical quantity like Length, Angle,etc using different measuring devices
02	Operation of different measuring devices like Tool makers microscope for measurement of diameter of screw threads, Gear nomenclatures, surface alignments etc.

7.0 Books Used and Recommended to Students

Text Books

1. Mechanical measurements and Metrology by Chetan Byrappa, Aswhin Gowda, Harish H V, Sunstar Publishers, 2017
2. Mechanical measurements and Metrology by Dr. T Chandrashekar, Subhas Stores publishers
3. Mechanical Measurements, Beckwith Marangoni and Lienhard, Pearson Education, 6th Ed., 2006.

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 Metrology and Measurements,**N.V.Raghavendra and L.Krishnamurthy, Oxford University Press.

Additional Study material & e-Books

1. Mechanical measurements by Beckwith maragoni and Lienhard, Pearson Education,

8.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References

http://www.tatynerds.com/mechanical-metrology-metrology
http: //www.vturesource.com/2011/01/mechanical-measurements
http://www.nptel.ac.in
http://www.sapnaonline.com/shop/Author/t-chandrashekar

9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	International Journal of measurement Technologies and Instrumentation Engineering	http://www.igi-global.com/journal/international-journal-measurement-technologies-instrumentation/43483
2	International Journal of Metrology and Quality Engineering	http://www.metrology-journal.org/

3	Springer Handbook of Metrology and Testing	http://www.springer.com/us/book/9783642166402
4	Measurement Techniques	http://www.springer.com/physics/applied+%26+technical+physics/journal/11018

10.0 Examination Note

Internal Assessment:

Theoretical aspects as well as relevant sketches should be drawn neatly for questions asked in Internal Assessments

Scheme of Evaluation for Internal Assessment (40 Marks)

(e) Internal Assessment test in the same pattern as that of the main examination (Better of the two Tests):25marks.

11.0 Course Delivery Plan

Module	Lecture No.	Content of Lecturer	% of Portion
1	101	Definition, objectives and concept of metrology	20%
	102	Need of inspection, Principles, process,	
	103	methods of measurement, Classification and selection of measuring instruments and systems	
	104	Accuracy, precision and errors in measurement	
	105	System of measurement, Material Standard, Wavelength Standards, Subdivision of standards,	
	106	Line and End standards, Classification of standards and Traceability, calibration of End bars(Numerical), standardization	
	107	Slip gauges- Indian standards on slip gauge, method of selection of slip Measurement of angles- sine bar, sine center, angle gauges gauge, stack of slip gauge, adjustable slip gauge, wringing of slip gauge,	
	108	care of slip gauge, slip gauge accessories, problems on building of slip gauges (M87, M112) Auto collimator-applications for measuring straightness and squareness	
2	109	Definition of tolerance, Specification in assembly, Principle of interchangeability and selective assembly	40%
	110	limits of size, Indian standards, concept of limits of size and tolerances,	
	111	definition of fits, hole basis system, shaft basis system, types of fits and their designation (IS 919-1963),	
	112	geometric tolerance, position-tolerances. Classification of gauges, brief concept of design of gauges (Taylor's principles),	
	113	Wear allowance on gauges, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials.	
	114	Functional requirements, classification	
	115	mechanical- Johnson Mikrokator, sigma comparators	
	116	dial indicator, electrical principles, , LVDT, Pneumatic- back pressure gauges, solex comparators optical comparators- Zeiss ultra-optimeter	
3	117	Terminology of screw threads, measurement of major diameter	60%
	118	minor diameter, pitch, angle and effective diameter of screw threads by 2-wire and 3- wire methods,	
	119	best size wire. Screw thread gauges, Tool maker's microscope. Gear tooth terminology, tooth thickness measurement using constant chord method,	
	120	addendum comparator method and base tangent method, measurement of pitch	
	121	Concentricity, run out, and involute profile. Gear roll tester for composite error	
	122	Basic concepts of lasers, advantages of lasers	
	123	laser interferometers, types	

	124	applications. Basic concepts of Coordinate Measuring Machines constructional features, applications, constructional features, applications	
4	125	Definition, significance of measurement, generalized measurement system	80%
	126	definitions and concept of accuracy, precision, calibration,	
	127	threshold, sensitivity, hysteresis, repeatability, linearity, loading effect, system response-time delay. Errors in measurement,	
	128	Classification of errors. Transducers, transfer efficiency, primary and secondary transducers,	
	129	Mechanical, electronic transducers, advantages of each type transducers.	
	130	Mechanical systems, inherent problems	
	131	electrical intermediate modifying devices	
	132	input circuitry, ballast circuit, Electronic amplifiers. Terminating devices Cathode ray oscilloscope, Oscillographs	
5	133	Direct methods and indirect method	100%
	134	force measuring inst. Torque measuring inst., Types of dynamometers, Absorption dynamometer	
	135	Prony brake and rope brake dynamometer, and power measuring instruments.	
	136	Pressure measurement, principle, use of elastic members	
	137	Bridgeman gauge, McLeod gauge, Pirani gauge.	
	138	Theory of strain gauges, types, electrical resistance strain gauge, preparation and mounting of strain gauges,	
	139	Gauge factor, methods of strain measurement. Temperature Compensation, Wheatstone bridge circuit,	
	140	Orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors. Resistance thermometers, thermocouple, law of thermocouple ,materials used for construction, pyrometer, optical pyrometer	

12.0 Assignments, Pop Quiz, Mini Project, Seminars

Sl.No.	Title	Outcome expected: students able to	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignment 1: Questions on Introduction to Metrology and Linear Measurement and angular measurements	Basic definitions and different standards	Module 1	2	Individual Activity.	Text Book 1
2	Assignment 2: Questions on System of Limits, Fits, Tolerance and Gauging and comparators	Describe different System of Limits, Fits, Tolerance and Gauging n	Module 2	4	Individual Activity.	Text Book 1
3	Assignment 3: Questions o Measurement of screw thread and gear and Advances	Describe different Measurement of screw thread and gear and advances in Metrology	Module 3	6	Individual Activity..	Text Book 2

	in metrology					
4	Assignment 4: Measurement systems and basic concepts of measurement methods	Understand the different measuring systems and different definition with reference to measurement systems	Module 4	8	Individual Activity.	Text Book 2
5	Assignment 5: Force, Torque and Pressure Measurement and Measurement of strain and temperature	Describe the function of different instruments used for measurement of force, torque, Pressure and Temperature	Module 5	8	Individual Activity.	Reference book 1

13.0 QUESTION BANK

Module I

Introduction to Metrology and Linear Measurement and angular measurements

1. Distinguish between line standards and end standards.
2. How are end standards derived from line standards? Give examples of these two types of standards.
3. Explain the role of light wave standard in the future of precision measurements.
4. What is the difference between line standards and end standards? How will you compare an end gauge with a line standard?
5. An NPL type level comparator has vial radius of 210 m, divisions 2.5mm apart and contact feet 25mm centre distance. Calculate the difference in length of two gauges under comparison. If the total bubbles displacement is 6 divisions.
6. Briefly describe the different types of standards for liner measurements.
7. Explain with neat figure the Standards of length - International prototype meter, Imperial standard yard, and Wave length standard,
8. Three 100mm end bars are measured on a level comparator by first wringing them together and comparing with a 300 mm bar and then inter comparing them. The 300 mm bar has a known error of +42 micrometer and the three bars together measure 64 micrometer less than the 300 mm bar. Bar A is 18 micrometer longer than bar B and 23 micrometer longer than bar C. find the actual length of each bar.
9. A calibrated meter end bar has an actual length of 1000.0005mm it is to be used in the calibration of two bars, A and B each having a basic length of 500 mm. When compared with the meter bar LA+LB was found to be shorter by 0.003mm. in comparing A with B it was found that A was 0.0006 mm longer than B. find the actual length of A and B.
10. Four length bars of basic length 100mm are to be calibrated using a calibrated length bar of 400 mm. whose actual length is 399.9992mm. it was also found that lengths of bars B C and D in comparison to A are +0.0002mm, +0.0004mm and -0.0001mm respectively and length of all the four bars put together in comparison to standard calibrated bar is +0.0003mm longer. Determine the actual dimensions of all the four end bars.
11. What is meant by Wringing of slip gauges?
12. Building of slip gauges for following lengths using (M-81, M-112) 123.1234, 324.985, 456.431.

Module II

System of Limits, Fits, Tolerance and Gauging and comparators

Define the following: with a neat figure

1 Fits
2 Basic size
3 Fundamental deviation

4 Allowances
5. Explain the principle if interchangeability and selective assembly.
6. What are compound tolerances? Explain
7. What is tolerance accumulation? Explain.
8. What is meant by geometrical tolerance?
9. Explain hole basis system and shaft basis of system.
10. Give the classification of gauges.
11. Explain the concept of design of gauges (Taylor's principles)?
12. What is wear allowance on gauges?
13. Write a note on gauge materials.
14. Calculate the dimensions of plug and ring gauges to control the production of 50 mm shaft and hole pair of H7d8 as per IS specifications. The following assumptions may be made: 50mm lies in diameter range of 30 and 50 mm and the upper deviation for the 'd' shaft is given by $-16D^{0.44}$ and lower deviation for hole H is zero. Tolerance factor and IT6=10i and above IT6 grade the tolerance magnitude is multiplied by 10 at each fifth step.
15. Determine the dimensions and tolerances of shaft and hole having size of 30 H7h8. Also determine the allowances and maximum clearances.
16. A hole and shafting system has the following dimensions 50H8c8. The standard tolerance is given by where D= dia in mm of geometric mean of steps and i= standard tolerance in microns. The multiplier for grade 8 is 25. The fundamental deviations for shaft c, for D>40mm is given by –(95+0.8D) microns. The diameter range lies between 50 to 80 mm. sketch the fit and show these upon the actual dimensions of hole and shaft. Determine the actual dimensions to be provided for a shaft and hole of 90 mm size for H8e9 type clearance fit. Size 90mm falls in the range of 80-100mm. Value of tolerance unit. Value of tolerance for IT8 and IT9 grades are 25i and 4i. Value of fundamental deviations for e type shaft is $-11D^{0.41}$.
17. What is a comparator? Classify the different types of comparators.
18. Describe the mechanical comparator and clearly explain the magnification method adopted in it.
19. Explain how pneumatic comparator works.
20. What is projection comparator? Show a sketch to illustrate the principle and give the type of works for which this instrument is specially suitable.
21. Explain with neat sketch the Johnson Mikrokator.
22. Explain with neat sketch Sigma Comparators.
23. What is dial indicator?
24. Explain the working principle of Optical Comparators.
25. With a neat figure explain the construction and working principle of LVDT.
26. Explain Solex Comparators.
27. What are the different ways of Angular measurements?
28. What is Sine Principle? And explain the use of Sine bars, Sine center.
29. Write short notes on

Module III
Measurement of screw thread and gear and Advances in metrology

1. Explain the Principle of interferometery?
2. Explain the working of autocollimator?
3. What are Optical flats? Explain
4. With a neat figure give the terminology of screw threads?
5. Explain the 2-wire and 3-wire methods,
6. Derive an expression for Best size wire.
7. With a neat sketch explain the use of Toolmakers microscope?
8. With a neat figure give gear terminology?
9. Explain the use of use of gear tooth vernier caliper and gear tooth micrometer.
10. What are the advances in Meterology
11. What is LASER
12. Explain the production of LASER
13. Explain the use of laser in Metrology

Module IV
Measurement systems and basic concepts of measurement methods

Define measurement and explain the generalized measurement system with neat block diagram.

1. Define
a. accuracy, b) precision, c) calibration, d) threshold, e) sensitivity, f) hystersis, g) repeatability h) linearity, i) loading effect, j) system response-times delay.
3. Classify Errors.
4. What is a Transducers? Explain Primary and Secondary transducers.
5. Write short notes on
a. Electrical transducer,
b. Mechanical transducer
c. Electronic transducer.
6. Write the advantages and disadvantages for the transducer in previous question.
7. List the inherent problems mechanical systems.
8. What are the Electrical intermediate modifying devices? Explain any one
9. Explain the ballast circuit.
10. What is telemetry?
11. With neat figure explain the working of Cathode Ray Oscilloscope.
12. Write short note on a) Oscillographs b) X-Y Plotters.

Module V

Force, Torque and Pressure Measurement and Measurement of strain and temperature

1. With a neat figure explain the working of analytical balance?
2. Explain the platform balance with neat figure?
3. What is proving ring? Explain.
4. List the torque measurement methods.
5. What is hydraulic dynamometer? Explain
6. Explain the Principle of pressure measurement with elastic members.
7. What is Bridgeman gauge? Explain with neat figure.
8. Explain the working of Mcloed gauge and Pirani Gauge.
9. Explain the principle of resistance thermometers.
10. Describe the law of thermocouple?
11. What materials are used for construction of thermocouple?
12. Write note on a) pyrometer b) optical pyrometer
13. What is Strain gauge? Explain with example.
14. Describe the preparation and mounting of strain gauges?
15. Define gauge factor.

14.0 University Result

Examination	S+	S	A	B	C	D	E	% Passing
2016 - 17	00	00	11	30	19	04	04	94.54
2017 - 18	02	07	26	20	05	02	-	96.92

Prepared by	Checked by		
Prof. B. M. Dodamani	Prof. G. A. Naik	HOD	Principal

17MEL37B- Mechanical Measurements and Metrology Laboratory

Subject Title	**Mechanical measurements and Metrology Laboratory**		
Subject Code	17MEL37B	**CIE**	40
No of Lecture Hrs + Practical Hrs/ Week	01+02	**SEE**	60
Total No of Lecture+Practical Hrs	52	**Exam Hours**	03
CREDITS – 02			

FACULTY DETAILS:		
Name: Prof. G A Naik	**Designation:** Asst.Professor	**Experience:**22Years
No. of times course taught: 10 Times	**Specialization:** Production Technology	
Name: Prof. B M Dodamani	**Designation:** Asst.Professor	**Experience:**07 Years
No. of times course taught:05Times	**Specialization:** Energy Systems Engineering	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Mechanical Engineering	I	Mechanical Engineering Science
02	Mechanical Engineering	III	Mechanical measurements and Metrology

2.0 Course Objectives

1. To learn various measuring methods, Principles of operation of instruments and different aspects of measurement systems
2. To know the different measuring instruments for measuring a physical quantity like length, Angle, Surface flatness
3. To know the specification, part details and their functions of measuring instruments

3.0 Course Outcomes

The student, after successful completion of the course, will be able to

CO	Course Outcome	Cognitive Level	POs
CO1	Use slip gauges and build slip gauges based on the dimensions	A	PO1, PO6, PO9
CO2	Operate thermometer with thermocouple reading, load cell using known weight, LVDT with respect to micrometer by spring core method	A	PO1, PO6, PO9
CO3	Estimate major and minor diameter, angle of screw thread using Toolmaker's microscope and using sine bar, sine center and bevel protractor can able to measure slope or angle of the given work piece.	A	PO1, PO6
CO4	Compute effective diameter of screw thread using three wire method and measure width & height of gear tooth at pitch circle diameter of a given gear using gear tooth vernier	A	PO1,PO9
CO5	Use autocollimator measure the surface finish i.e straightness and flatness of the surface	A	PO1,PO6,PO9
CO6	Use optical flats with the help of monochromatic light source to check whether the given work piece surface is perfectly flat, either concave or convex.	U	PO1,PO6,PO9
Total Hours of instruction		**52**	

4.0 Course Content

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

1. Measurements using Optical Projector / Toolmaker Microscope.
2. Measurement of angle using Sine Center / Sine bar / bevel protractor
3. Measurement of alignment using Autocollimator / Roller set
4. Measurement of cutting tool forces using

a) Lathe tool Dynamometer OR
b) Drill tool Dynamometer.

5. Measurements of Screw thread Parameters using two wire or Three-wire methods.
6. Measurements of Surface roughness, Using Tally Surf/Mechanical Comparator
7. Measurement of gear tooth profile using gear tooth Vernier /Gear tooth micrometer
8. Calibration of Micrometer using slip gauges
9. Measurement using Optical Flats

5.0 Relevance to future subjects

SL. No	Semester	Subject	Topics / Relevance
01	III / IV	Mechanical measurements and Metrology Lab	Provides basics of measurement process and different measurement systems and measuring instruments to be used in MMM Lab
02	VIII	Project work	Generation of components for project

6.0 Relevance to Real World

SL.No	Real World Mapping
01	Measuring a physical quantity like Length, Angle,etc using different measuring devices
02	Operation of different measuring devices like Tool makers microscope for measurement of diameter of screw threads, Gear nomenclatures, surface alignments etc.

7.0 Books Used and Recommended to Students

Text Books
Mechanical measurements and Metrology by Dr. T Chandrashekar, Subhas Stores publishers
Reference Books
1. Engineering Metrology by R. K. Jain,Khanna Publishers 2. Mechanical metrology by I. C. Gupta Dhanapat Rai Publications, Delhi
Additional Study material & e-Books
1. Mechanical measurements by Beckwith maragoni and Lienhard, Pearson Education,

8.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References
1. http://www.tatynerds.com/mechanical-metrology-metrology 2. http: //www.vturesource.com/2011/01/mechanical-measurements

3.	http://www.nptel.ac.in
4.	http://www.sapnaonline.com/shop/Author/t-chandrashekar

9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	International Journal of measurement Technologies and Instrumentation Engineering	http://www.igi-global.com/journal/international-journal-measurement-technologies-instrumentation/43483
2	International Journal of Metrology and Quality Engineering	http://www.metrology-journal.org/
3	Springer Handbook of Metrology and Testing	http://www.springer.com/us/book/9783642166402
4	Measurement Techniques	http://www.springer.com/physics/applied+%26+technical+physics/journal/11018

10.0 Examination Note

Internal Assessment:
Theoretical aspects as well as relevant sketches should be drawn neatly for questions asked in Internal Assessments
Scheme of Evaluation for Internal Assessment (20 Marks)
(f) Internal Assessment test in the same pattern as that of the main examination (Better of the two Tests):25marks.

SCHEME OF EXAMINATION:

One question from Part-A	30
One question from Part-B	50
Viva–Voce	20
Total	100 Marks

11.0 Course Delivery Plan

Expt No	Lecture/Practical No	Name of the Experiment	% Of Portion
1	1	To study slip gauges and build up a slip gauge for given dimension	47.61
2	2	To calibrate the given vernier caliper.	
3	3	To calibrate the given micrometer	
4	4	To measure the angle using sine bar	
5	5	To measure the angle of tapered work using sine center	
6	6	To study Toolmaker's microscope and measure angle of screw thread using Toolmaker's microscope.	
7	7	To study the use of bevel protractor & to measure the angle	
8	8	To calibrate given load cell (load transducer) with help of fulcrum weights	26.19
9	9	To determine strain of a cantilever beam (AL) using strain gauges	
10	10	Measurement of effective diameter of screw thread using three-wire method	
11	11	To measure width & height of gear tooth at pitch circle diameter of a given gear.	
12	12	Calibration of LVDT with respect to micrometer by spring core method.	26.19
13	13	Calibration of thermocouple using glass thermometer	
14	14	To determine the straightness & flatness of the surface by using Autocollimator	

15	15	To study the flatness of the surfaces (Concave, Convex & Flat) by using the optical flats.	

12.0 QUESTION BANK

1. Define pressure?
2. Explain the bourdon tube pressure gauge
3. List the different pressure measuring instruments.
4. What is temperature?
5. List the different types of temperature measuring instruments.
6. Explain the principle of thermocouple.
7. What is calibration of thermocouple?
8. Different ways of displacement measurement.
9. Explain the working of LVDT.
10. What is strain gauge?
11. What is load cell?
12. Discuss the arrangement of strain gauges in load cell.
13. What is tool maker's microscope
14. Discuss the use of tool maker's microscope for thread measurement.
15. What are the different methods of measuring angles?
16. What is sine centre?
17. What is sine bar?
18. What is bevel protractor?
19. What are angle gauges?
20. Explain the working principle of autocollimator.
21. List the screw thread parameters.
22. What are different types of threads?
23. What is least count?
24. Calculate the least count of screw gauge, vernier caliper.
25. What are optical flats?
26. Explain the working principle of optical flats.
27. When bright fringes are formed?
28. When dark fringes are formed?
29. What is the function
30. What are optical flats?
31. Definf effective diameter of screw thread
32. What is gear?
33. What is Autocollimator?
34. Define Pitch?
35. What is the function of collimator lens?

13.0 University Result

Examination	FCD	FC	SC	% Passing
July 2016				
July 2015				

Prepared by	Checked by		
Prof. G. A. Naik	Prof. B. M. Dodamani	HOD	Principal

17MEL38B- Machine Shop

Subject Title	MACHINE SHOP LABORATORY		
Subject Code	17MEL38B	CIE Marks	40
No of Lecture Hrs + Practical Hrs/ Week	01+02	Exam Marks	60
Total No of Lecture+Practical Hrs	50	Exam Hours	03
CREDITS – 02			

FACULTY DETAILS:		
Name: Prof.Ravi.K.Chitgopkar	**Designation:** Asst.Professor	**Experience:**29Years
No. of times course taught:05 Times	**Specialization:** Thermal Power Engineering	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Mechanical Engineering	I	EME
02	Mechanical Engineering	III	Manufacturing Process I
03	Mechanical Engineering	IV	Manufacturing Process II

2.0 Course Objectives

1 To provide an insight to different machine tools, accessories and attachments
2 To train students into machining operations to enrich their practical skills
3 To inculcate team qualities and expose students to shop floor activities
4 To educate students about ethical, environmental and safety standard.

3.0 Course Outcomes

The student, after successful completion of the course, will be able to

CO	Course Outcome	RBT Level	POs
CO1	Able to carry out any kind of operation on Machine tools (Lathe)	L1,L2,L3	PO1, PO6, PO9
CO2	Capable of preparing various types of jobs accurately to the given dimensions	L1,L2,L3	PO1, PO6, PO9
CO3	Able to perform groove cutting and gear cutting operations.	L1,L2,L3	PO1, PO6
Total Hours of instruction		**50**	

4.0 Course Content

PART A

PART – A
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.

PART – B
Cutting of V Groove/ dovetail / Rectangular groove using a shaper Cutting of Gear Teeth using Milling Machine

PART –C
For demonstration of formation of cutting parameters of single point cutting tool using bench grinder / tool & cutter grinder. Demonstration of surface milling /slot milling

5.0 Relevance to future subjects

SL. No	Semester	Subject	Topics / Relevance
01	IV	Machine tool and operations	Provides basics of machine tools to be used in Machine Shop Lab
02	VIII	Project work	Generation of components for project

6.0 Relevance to Real World

SL.No	Real World Mapping
01	Producing different models by machining process.
02	Producing ancillary products for assembly of machines.

7.0 Books Used and Recommended to Students

Text Books
1. Workshop Technology by HazraChaudharyvol I &vol II. 2. Fundamentals of metal cutting and Machine tools By B L Juneja
Reference Books
3. Machine Tool Operations By Anup Goel 4. Metal Processing II BY Kestoor Praveen
Additional Study material & e-Books
A Textbook of Metal processing eBook By O P Khanna PDF.

8.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

Website and Internet Contents References
https://en.wikipedia.org/wiki/Machine_shop https://www.ameslab.gov/mpc/equipment/machine-shop http://www.nptel.ac.in

9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	International Journal of Machine tool and manufacture	www.journals.elsevier.com/international-journal-of-machine-tools-and-manufacture
2	International Journal of Mechanical and Materials Engg	http://www.springer.com/engineering/mechanics/journal/40712
3	International Journal of Precision engg and manufacturing	http://www.springer.com/engineering/production+engineering/journal/12541
4	International Journal of Machine tool design and Research	http://www.sciencedirect.com/science/journal/00207357

10.0 Examination Note

Internal Assessment:
Theoretical aspects as well as relevant sketches should be drawn neatly for questions asked in Internal Assessments
Scheme of Evaluation for Internal Assessment (40 Marks)
(g) Internal Assessment test in the same pattern as that of the main examination
SCHEME OF EXAMINATION:

One Model from Part – A 50 Marks
One Model from Part – B 30
Marks Viva Voce 20
Marks Total 100 Marks

11.0 Course Delivery Plan

Expt No	Lecture/Practical No	Name of the Experiment	% Of Portion
1	16	Introduction to various machine tools.	47.61
2	17	Facing and plain turning	
3	18	Knurling and thread cutting	
4	19	Taper turning and eccentric turning	
5	20	V groove cutting and rectangular groove cutting	
6	21	To study the indexing and milling machine operation	
7	22	Perform gear tooth cutting on milling machine	
8	23	To understand the cutting tool parameters of single point cutting tool using bench grinder	42.39
9	24	Understand surface milling/slot milling	
10	25	Demonstrate the precautions and safety measures followed in machine shop	
11	26	Kea way cutting/slot cutting on shaper	

12.0 QUESTION BANK

1. 1.Define lathe 2. List the operations performed on the lathe 3. What are the principal parts of the lathe? 4. Various parts mounted on the lathe? 5. Mention the types of head stock 6. Mention the four types of tool post 7. What is an apron? 8. Mention the specifications of the lathe 9. List the types of lathe 10. Define semi automatic lathe 11. State the various feed mechanisms of the lathe 12. List 4 holding devices 13. Define 'Conicity'? 14. Advantages of capstan lathe and turret lathe. 15. Define tooling 16. What are 3 stage tool layout 17. Define shaper 18. List and explain Important parts of shaper. 19. Driving Mechanism involved in shaper 20. List and explain Shaping operations 21. Principle of shaping 22. Classification of shaping machine 23. Specifications of milling machine 24. Specifications of milling machine	25. Comparison between universal and plain milling machine 26. What are cutter holding devices 27. Operations of milling machines and explain each of them. 28. Milling cutter nomenclature 29. Advantages of milling machine 30. Define indexing 31. Explain Universal dividing head 32. What is cam milling? 33. Explain spur gear cutting 34. Various parts of single point cutting tool 35. Define tool signature 36. What is the effect of back rake angle and mention its type 37. What is side rake angle and mention its effects? 38. Conditions for positive rake angle 39. Conditions for negative rake angle 40. Define orthogonal and oblique cutting 41. Define cutting force 42. Chip thickness ratio 43. Factors affecting machinability 44. Define machinabilty of metal? 45. What is machinabilty index? 46. How tool life is defined

13.0 University Result

Examination	FCD	FC	SC	% Passing
Dec 2017-18	57	00	00	100
July 2016	62	00	00	100
July 2015	53	13	03	98.57

Prepared by	Checked by		
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