Department of Mechanical Engineering

COURSE PLAN 2019-20

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.	Additional Responsibility	Contact Person	
		Faculty	Staff
1.	Attestations, Dept. & Institute Work.	HOD	Sri. V G Badiger
2.	PG Coordinator/ Research Centre Head	Prof. S A Alur	Sri. R M Hunchyali
3.	I I I coordinator (INDUSTRY)	Prof. G A Naik	Sri. S C Jotawar
4.	I I I coordinator (INTERNSHIP)	Prof. R. V. Chitgopkar	Sri. R B Kumbar
5.	Class Teachers In-charges	Prof.K.M.Akkoli (III A)	Sri. M S Kurani
		Prof.Jagadeesh S A (III B)	Sri. R B Kumbar
		Prof.M. R. Ingalagi (V A)	Sri. R M Hunchyali
		Prof. R.K.Chitagopkar (V B)	Sri. S R Nakade
		Prof.S.A.Goudadi (VII A)	Sri. S C Jotawar
		Prof. M S Futane (VII B)	Sri. M B Badiger
6.	Record Room Coordinator	Prof. S. B. Awade	Sri. M S Kurani
7.	I A Test Coordinator	Prof. S. B. Awade/Prof. A M Biradar	Sri. M B Badiger
8.	Seminar/Project Coordinator	Prof. N.M.Ukkali/ Prof. B. M. Dodamani	Sri. M B Badiger/ Sri. S C Jotawar
9.	Faculty / AICTE/LIC/ Staff Activities	Prof. B. M. Dodamani	All Instructors
10.	Student Activities/Feedback Coordinator	Prof. Jagdeesh A	
11.	AIMSS Coordinator	Prof. M. M. Shivashimpi/Prof. M R Ingalagi	Sri. M B Badiger
12.	NBA Coordinator	Prof. S. A. Goudadi	
13.	Extra Curricular/ Induction Coordinator	Prof. T S Vandali	
14.	Dept. Meeting Proceedings Coordinator	Prof. K G Ambli	
15.	PhD.EMS/ News Letter Coordinator	Prof. M. M. Shivashimpi	
16.	Choice of Electives	Dr. S. N. Toppannavar Prof. D. N. Inamdar Prof. T. S. Vandali	
17.	EMS Coordinator	Prof. S. B. Awade/ Prof. N.M.Ukkali/ Prof. M R Ingalagi	
18.	T P Cell Coordinator	Prof. R V Nyamagoud	Sri S. R. Nakade
19.	Alumni Coordinator.	Prof. M A Hipparagi	
20.	Robo Vidya Coordinator	Prof. A M Biradar	Sri. V G Badiger
21.	Department Library Coordinator	Sri. Mahantesh Tanodi	Sri. R M Hunchyali
22.	Time Table/ISTE Coordinator	Prof. G. V. Chiniwalar	
23.	GATE Coordinator	H.O.D	
24	News Letter/ Tech. Magazine/ Coordinator,	Prof. S R Kulkarni/ Prof. M S Futane	
25	Central Counseling Coordinator (Dept.)	HOD & Class Teachers	
26	Dispensary	Dr. Arun G. Bullannavar - Cell No. 9449141549	
Institute Level			
01	NBA/NIRF Coordinator	Prof. D. N. Inamdar (9591208980)	
02	Student Welfare Convener	Prof. S. B. Akkoli (9480422508)	
03	Hostel warden KSCST Coordinator	Prof. M S Futane (7829611609)	
04	AICTE/ Hostel Asst. Warden Coordinator	Prof. K. M. Akkoli (9739114856)	
05	TP Cell Coordinator	Prof. N. M. Patel (9739619661)	
06	Anti Ragging Convener	Prof. M. S. Futane (9480849334)	
07	Anti Squad Convener	Prof. K. M. Akkoli (9739114856)	
08	Anti Sexual Harassment Convener	Prof.S.S.Kamate (9008696825)	
09	Grievance Redressal Convener	Prof. G. A. Naik (9480539283)	
10	Institute News & publicity	Prof. Mahesh Hipparagi (7411507405)	
11	First Year Coordinator	Dr. S. N. Toppannavar (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	24	17
2	Technical staff	11	14
3	Helper / Peons	05	09

Major Laboratories

S.N.	Name of the laboratory	Area in Sq. Meters	Amount Invested (Rs.)
1	Basic Workshop Laboratory	170	427698
2	Fluid Mechanics Machinery Laboratory	172	775316.75
3	Energy Conversion Engg. Laboratory	173	1269190.2
4	Machine shop Laboratory	170	1361344.5
5	Foundry & Forging Laboratory	179	318787.11
6	Design Laboratory	73	364998
7	Heat & Mass Transfer Laboratory	148	524576
8	Metallography & Material Testing Laboratory	149	1095679.24
9	Mechanical Measurements & Metrology Laboratory	95	548011.75
10	CIM & Automation/CAMA Laboratory	66	3720223.1
11	Computer Aided Machine Drawing Laboratory	66	2013811.5
12	Computer Aided Engg Drawing Laboratory	66	1427271.3
13	Department/Other	--	1908664.2
	Total	**1527**	**1,57,55,571.65**

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	26	9480849331
2	Dr. S. A. Alur	Professor	Ph. D	Thermal Power Engg.	LMISTE	--	24	9686856029
3	Dr. B M Shrigiri	HOD/Professor	Ph. D	Thermal Power Engg.	LMISTE	01	20	9741483339
4	Dr. S. N. Topannavar	Assoc. Professor	M Tech.(Ph. D)	Thermal Power Engg.	LMISTE	01	18	9482440235
5	Prof. D. N. Inamdar	Asso. Professor	M Tech.(Ph. D)	Tool Engg	LMISTE	08	14	9591208980
6	Prof. K. M. Akkoli	Asso. Professor	M Tech.(Ph. D)	Thermal Power Engg.	LMISTE	1.5	14	9739114856
7	Prof.R.K.Chitgopkar	Asst. Professor	M Tech.	Thermal Power Engg.	LMISTE	1.5	26	9886070475
8	Prof.G. A. Naik	Asst. Professor	M Tech.	Production Management	LMISTE	02	21	9480539283
9	Prof. G. V. Chiniwalar	Asst. Professor	M Tech.	Machine Design	LMISTE	04	14	8762336434
10	Prof.M.S.Futane	Asst. Professor	M Tech.	Computer Integrated Manufacturing	LMISTE	01	12	9164105035
11	Prof. T. S. Vandali	Asst. Professor	M Tech.	Machine Design	LMISTE	8.5	08	9686235904
12	Prof.S. A. Goudadi	Asst. Professor	M Tech.	Design Engineering	LMISTE	--	10	9448876682
13	Sri. S.R. Kulkarni	Asst. Professor	M Tech.	Design Engineering	LMISTE	--	10	8123661692
14	Prof.M.M.Shivashimpi	Asst. Professor	M Tech.(Ph.D)	Thermal Power Engg.	LMISTE	01	08	9742197173
15	Prof.M.A.Hipparagi	Asst. Professor	M Tech.(Ph.D)	Production Technology	LMISTE	02	07	7411507405
16	Prof. A. M. Biradar	Asst. Professor	M Tech.	Machine Design	LMISTE	02	07	9986127703
17	Prof. K. G. Ambli	Asst. Professor	M Tech.(Ph.D)	Product Design and Manufacturing	LMISTE	0.8	06	9164534514
18	Prof. S. B. Awade	Asst. Professor	M Tech.	Machine design	LMISTE		05	9632606108
19	Prof.Mahantesh Tanodi	Asst. Professor	M Tech.	Machine design	LMISTE	--	06	9611998812
20	Prof. N. M. Ukkali	Asst. Professor	M Tech.	Machine Design	LMISTE	--	05	9620152199
21	Prof. M. R. Inagalagi	Asst. Professor	M Tech.	Thermal Power Engg	LMISTE	--	04	9743868503
22	Prof. Jagadeesh A.	Asst. Professor	M Tech.	Thermal Power Engg	LMISTE	--	05	9902847774
23	Prof. R. V. Nyamagoud	Lecturer	M Tech.	Thermal Power Engg	LMISTE	--	04	9964822494
24	Prof. B. M. Dodamani	Asst. Professor	M Tech.	Energy System Engg	LMISTE	02	04	9535447575

CALENDAR OF EVENTS FOR THE ACADEMIC YEAR 2019-20 (Odd)

Date	Events
29-07-2019	Commencement of III /V/VII Sem Classes
01-08-2019	Commencement of I Sem Classes
01-08-2019 to 11-08-2019	Induction Program for I Sem students
15-08-2019	Independence Day & Swachh Bharat Abhiyan
05-09-2019	Teachers Day, Mahadasoha
06-09-2019	Indoor Games & & Health Checkup Camp
12-09-2019 to 14-09-2019	First Internal Assessment of I/III/V/VII Sem
15-09-2019	Engineers Day
16-09-2019	Feed Back-1 on Teaching-Learning
18-09-2019	Display of First Internal Assessment Marks & Submission of Feedback-1 report to office
24-09-2019	EDP Activities/ Green Club activites
02-10-2019	Gandhi Jayanti & Swachh Bharat Abhiyan
11-10-2019	Blood donation camp
21-10-2019 to 23-10-2019	Second Internal Assessment of I/III/V/VII Sem
24-10-2019	Feed Back-2 on Teaching-Learning
28-10-2019	Display of Second Internal Assessment Marks & Submission of Feedback-2 Report to Office
01-11-2019	Kannada Rajyotsava
21-11-2019 to 23-11-2019	Third Internal Assessment of I/III/V/VII Sem
25-11-2019 to 27-11-2019	Lab Internal Assessment of I/III/V/VII Sem
28-11-2019	Display of Third & Final Internal Assessment Marks (I/III/V/VII Sem)
29-11-2019	Last Working Day of I Sem
30-11-2019	Last Working Day of III/V/VII Sem
03-12-2019 to 13-12-2019	Practical Exams of I/III/V/VII Sem
16-12-2019 to 07-02-2020	Theory Exams of I/III/V/VII Sem

August-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

12-Bakrid, 15- Independance day, 26- Last Shravana Monday

September-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					

02- Ganesh Chaturthi , 05- Mahadasoha, 10- Moharam, 28-Mahalaya Amavasye

October-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		

02- Gandhi Jayanti, 07-Ayudha Pooja, 08- Vijayadashami, 13- Valmiki Jayanti, 27- Naraka Chaturdashi, 29- Balipadyami

November-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

01- Kannada Rajyotsava, 10- Id-e-Milad, 15- Kanakadasa Jayanthi

Dr. Shilpa Shrigiri
IQAC Co-ordinator

Hirasugar Institute of Technology Nidasoshi Pin-591236 Dt. Belagavi

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

DEPARTMENT CALENDAR OF EVENTS FOR THE ACADEMIC YEAR 2019-20 (Odd)

Date	Events
29-07-2019	**Commencement of III /V/VII Sem Classes**
17-08-2019	**Welcome Function for Fresher's and Inauguration of AIMSS Activities**
31-08-2019	Industrial Visit for III semester students
06-09-2019	Technical Talk by environmentalist
12-09-2019 to 14-09-2019	**First Internal Assessment**
16-09-2019	Feedback - 01 on Teaching and Learning
18-09-2019	Display of First I.A. Marks, Submission of Students Feedback-1 report and Central Counseling.
21-09-2019	Industrial Visit for V semester students
24-09-2019	ED Cell Activity
11-10-2019	Technical Talk by Academic Expert
21-10-2019 to 23-10-2019	**Second Internal Assessment**
24-10-2019	Feedback - 02 on Teaching and Learning
28-10-2019	Display of Second I.A. Marks, Submission of Feedback-2 Report to Office and Central Counseling.
08-11-2019	Technical Talk by Industry Expert
21-11-2019 to 23-11-2019	**Third Internal Assessment**
25-11-2019 to 27-11-2019	**Lab Internal Assessment**
28-11-2019	Display of Third & Final I.A. Marks
30-11-2019	**Last Working Day**
03-12-2019 to 13-12-2019	**Commencement of Practical Exams**
16-12-2019 to 07-02-2020	**Commencement of Theory Exams**

August-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

12-Bakrid, 15- Independance day, 26- Last Shravana Monday

September-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					

02- Ganesh Chaturthi , 05- Mahadasoha, 10- Moharam, 28-Mahalaya Amavasye

October-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		

02- Gandhi Jayanti, 07-Ayudha Pooja, 08- Vijayadashami, 13- Valmiki Jayanti, 27- Naraka Chaturdashi, 29- Balipadyami

November-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

01- Kannada Rajyotsava, 10- Id-e-Milad, 15- Kanakadasa Jayanthi

Prof. M. M. Shivashimpi
AIMSS Co-ordinator

Dr. B. M. Shrigiri
HOD

HOD
Mechanical Engg.
HIT, Nidasoshi

Scheme of Teaching and Examination

3rd Semester "B" division

III SEMESTER

Course and Course Code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
				Theory Lecture	Tutorial	Practical/ Drawing	Duration in hour	CIE Marks	SEE Marks	Total Marks	
				L	T	P					
BSC	18MAT31	Mathematics	Mathematics	2	2	--	03	40	60	100	3
PCC	18ME32	Mechanics of Materials		3	2	--	03	40	60	100	4
PCC	18ME33	Basic Thermodynamics		3	0	--	03	40	60	100	3
PCC	18ME34	Material Science		3	0	--	03	40	60	100	3
PCC	18ME35B	Metal Casting And welding		3	0	--	03	40	60	100	3
PCC	18ME36B	Mechanical Measurements and Metallurgy		1	4	--	03	40	60	100	3
PCC	18MEL37B	Mechanical Measurements and Metrology lab		--	2	2	03	40	60	100	2
PCC	18MEL38B	Foundry, forging and Welding Lab		--	2	2	03	40	60	100	2
	18CPH39	Constitution of India, Professional Ethics and Cyber Law		1	--	--	03	40	60		
				Examination is by objective type questions							

VTU Scheme

III SEMESTER

Sl. No	Course and Course Code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	BSC	18MAT31	Mathematics	Mathematics	2	2	--	03	40	60	100	3
2	PCC	18ME32	Mechanics of Materials		3	2	--	03	40	60	100	4
3	PCC	18ME33	Basic Thermodynamics		3	0	--	03	40	60	100	3
4	PCC	18ME34	Material Science		3	0	--	03	40	60	100	3
5	PCC	18ME35A or	Metal cutting and forming		3	0	--	03	40	60	100	3
		18ME35B	Metal Casting and Welding									
6	PCC	18ME36A or	Computer Aided Machine Drawing/		1	4						
		18ME36B	Mechanical Measurements and Metallurgy		3	0	--	03	40	60	100	3
7	PCC	18MEL37A or	Material Testing lab		--	2	2	03	40	60	100	2
		18MEL37B	Mechanical Measurements and Metrology lab									
8	PCC	18MEL38A	Workshop and Machine Shop Practice (Consists of Fitting, and Machining)		--	2	2	03	40	60	100	2
		18MEL38B	Foundry, Forging and Welding lab									
9	HSMC	18KVK39/49	Vyavaharika Kannada (Kannada for communication)/	HSMC	--	2	--	--	100	--	100	1
		18KAK39/49	Aadalitha Kannada (Kannada for Administration)									
		OR										
		18CPH39	Constitution of India, Professional Ethics and Cyber Law		1	--	--	03	40	60		
					Examination is by objective type questions							
				TOTAL	**17**	**10**		**24**	**420**	**480**		
					OR	**OR**	**04**	**OR**	**OR**	**OR**	**900**	**24**
					19	**14**		**27**	**360**	**540**		

	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. Accredited at 'A' Grade by NAAC and Recognized Under Section 2(f) of UGC act1956.	**Mech. Engg.** **Course Plan** **III Sem.B** **2019-20 (Odd)**

Subject Title	**TRANSFORM CALCULUS, FOURIER SERIES AND NUMERICAL TECHNIQUES**		
Subject Code	18MAT31	**IA Marks**	40
Number of Lecture Hrs / Week	04	**Exam Marks**	60
Total Number of Lecture Hrs	50	**Exam Hours**	03
CREDITS – 03			

FACULTY DETAILS:		
Name: 1) Prof. S. A.Patil 2) Prof.S. I. Shivamoggimath	Designation: 1)Asst. Professor 2)Asst. Professor	Experience: 1) 09 2) 6.5
No. of times course taught: 1) 7 2) 4	**Specialization:** Mathematics	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Mechanical Engineering	II	Advanced Calculus & Numerical Methods

2.0 Course Objectives

Course Learning Objectives:

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

3.0 Course Outcomes

On completion of this course, students are able to:

	Course Outcome	POs
CO1	Use Laplace transform and inverse Laplace transform in solving differential/ integral equation arising in network analysis, control systems and other fields of engineering.	1,2,3
CO2	Demonstrate Fourier series to study the behavior of periodic functions and their applications in system communications, digital signal processing and field theory.	1,2,3
CO3	Make use of Fourier transform and Z-transform to illustrate discrete/continuous function arising in wave and heat propagation, signals and systems.	1,2,3
CO4	Solve first and second order ordinary differential equations arising in engineering problems using single step and multistep numerical methods.	1,2,3
CO5	Determine the externals of functional using calculus of variations and solve problems arising in dynamics of rigid bodies and vibrational analysis.	1,2,3
Total Hours of instruction		50

4.0 Course Content

MODULES	RBT Levels	No. Of Hours
MODULE-1 **Laplace Transform:** Definition and Laplace transforms of elementary functions (statements only). Laplace transforms of Periodic functions (statement only) and unit-step function – problems. **Inverse Laplace Transform**: Definition and problems, Convolution theorem to find the inverse Laplace transforms (without Proof) and problems. Solution of linear differential equations using Laplace transforms.	**L1,L2**	**10**
MODULE-2 **Fourier Series**: Periodic functions, Dirichlet's condition. Fourier series of periodic functions period 2π and arbitrary period. Half range Fourier series. Practical harmonic analysis.	**L1, L2**	**10**
MODULE-3 **Fourier Transforms:** Infinite Fourier transforms, Fourier sine and cosine transforms. Inverse Fourier transforms. Problems. **Difference Equations and Z-Transforms:** Difference equations, basic definition, z-transform-definition, Standard z-transforms, Damping and shifting rules, initial value and final value theorems (without proof) and problems, Inverse z-transform and applications to solve difference equations.	**L1, L2**	**10**
MODULE-4 **Numerical Solutions of Ordinary Differential Equations(ODE's)**: Numerical solution of ODE's of first order and first degree- Taylor's series method, Modified Euler's method. Runge -Kutta method of fourth order, Milne's and Adam-Bash forth predictor and corrector method (No derivations of formulae)-Problems.	**L1, L2**	**10**
MODULE-5 **Numerical Solution of Second Order ODE's:** Runge-Kutta method and Milne's predictor and corrector method. (No derivations of formulae). **Calculus of Variations:** Variation of function and functional, variational problems, Euler's equation, Geodesics, hanging chain, problems.	**L1,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 sampling is the reduction of a to a. A common example is the conversion of a (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: Calculus of Variations

8.0 Books Used and Recommended to Students

Text Books

1) 'B.S. Grewal, Higher Engineering Mathematics, 44th Edition 2017, Khanna Publishers.
2) E. Kreyszig: Advanced Engineering Mathematics, John Wiley & Sons, 10th Ed., 2016.
3) Srimanta Pal et al Engineering Mathematics, 3rd Edition, 2016, Oxford University Press.

Reference Books

1 N P Bali and Manish Goyal, "A text book of Engineering mathematics" , Laxmi publications, 6th Edition, 2014.
2. B.V.Ramana "Higher Engineering M athematics" Tata McGraw-Hill, 11th Edition, 2010 .
3. H. K Dass and Er. RajnishVerma ,"Higher Engineerig Mathematics", S. Chand Publishing, 1st Edition, 2011.
4. C. Ray Wylie,Louis C. Barrett "Advanced Engineering Mathematics" ,McGraw-Hill Book Co, 6th Edition, 1995
5. Chandrika Prasadand Reena Garg, "Advanced Engineering Mathematics", Khanna Publishing,2018

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

Web links and Video Lectures:

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

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 **four** 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	Definition, transforms of elementary functions	20
	2	Properties	
	3	Problems	
	4	Periodic function	
	5	Unit step function	
	6	Problems	
	7	Inverse Laplace Transforms	
	8	Convolution theorem	
	9	Solution of linear differential equations using Laplace Transforms	
	10	Problems	
MODULE-2	11	Introduction, Periodic functions, Dirichlet's conditions	20
	12	Fourier series of periodic functions of period 2π	
	13	Fourier series of periodic functions of arbitrary period 2c	
	14	Problems	
	15	Fourier series of even functions	
	16	Fourier series of odd functions	
	17	Problems	
	18	Half range Fourier series	
	19	Practical harmonic analysis	
	20	Problems	
MODULE-3	21	Introduction, Infinite Fourier transform	20
	22	Fourier sine transforms	
	23	Fourier cosine transforms	
	24	Inverse transforms	
	25	z-transform-definition	
	26	Standard z-transforms	
	27	Damping rule, Shifting rule	
	28	Initial value and final value theorems (without proof) and problems	
	29	Inverse z-transform	
	30	Applications of z-transforms to solve difference equations	
MODULE-4	31	Numerical solution of ordinary differential equations of first order & first degree	20
	32	Taylor's series method & Problems.	
	33	Modified Euler's method	
	34	Problems	
	35	Runge -Kutta method of fourth order	
	36	Problems	
	37	Milne's predictor and corrector method	
	38	Problems	
	39	Adams-Bashforth predictor and corrector method	

	40	Problems.	
MODULE-5	41	Numerical solution of second order ordinary differential equations	**20**
	42	Runge -Kutta method	
	43	Problems.	
	44	Milne's method	
	45	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: University Questions	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 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-1: Laplace & Inverse Laplace Transform;

1. Find the Laplace Transform of sin2t sin3t. & $\sin^3 2t$.
2. Find L (e^{3t}sin2t) & L (e^{4t} sin2tcost).
3. Find L[1-e^t]/t & L[cosat-cosbt/t]

4. Using unit step function find LT of $f(t) = \begin{cases} \sin t, & 0 < t < \pi \\ \sin 2t, & \pi < t < 2\pi \\ \sin 3t, & t > 2\pi \end{cases}$
5. Express $f(t) = \begin{cases} \cos t, & 0 < t < \pi \\ \cos 2t, & \pi < t < 2\pi \\ \cos 3t, & t > 2\pi \end{cases}$ in terms unit step function & hence find LT
6. Evaluate $L[t^2u(t-3)]$.
7. Find the inverse transform $s+2/s^2-4s+13$.
8. Find $L^{-1}[\ 4s+5/(s-1)^2(x+2)]$
9. Find $L^{-1}[\ s/s^4+4a^4]$.
10. Find $L^{-1}[\ s/(s^2+a^2)^2]$.
11. Find $L^{-1}[\ \log(s+1/s-1)]$
12. Find $L^{-1}[\ (s/(2s-1)(3s-1)]$.
13. Using the Convolution THM obtain the $L^{-1}[\ s/(s^2+a^2)2]$.
14. Solve the differential equation $d^2y/dx^2-3dy/dx+2y = e^{3t}$ with y(0)=0=y'(0), using LT
15. Solve the differential equation $y''+4y'+3y=e^{-t}$, y(0) =1= y'(0). Using LT

Module-2: Fourier series:

1. Obtain a Fourier series to represent e^{-ax} from $(-\pi, x)$
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 |, $-\pi < x < \pi$, 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 $0 \le x \le 1$
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) = 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-3: 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

$f(x) = \begin{cases} x, & |x| \leq \\ 0, & |x| > \alpha \end{cases}$ Where α is a positive constant?

3. Find the Fourier transform of $\cos ax^2$
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-4: Numerical Methods

1. Solve $\frac{dy}{dx} = x^2y - 1$with y(0)=1 using Taylor's series method and find y(0.1) consider upto 4th degree terms.
2. Use Runge Kutta fourth order method to solve $\frac{dy}{dx} = \frac{y^2-x^2}{y^2+x^2}$ with y(0)=1 and find y for x= 0.2 and 0.4 take h=0.2
3. Given $\frac{dy}{dx} = xy + y^2$, y(0)=1, y(0.1) =1.1169 ,y(0.2)=1.2773, y(0.3)=1.5049 find y(0.4) accurate upto three decimal places using Milne's predictour corrector method.
4. Applying R-K method to find an approximate value of y for x=0.2 in steps of 0.1 of $\frac{dy}{dx} = x + y^2$ given that y=1 when x=0.
5. Given $\frac{dy}{dx} = x^2(1 + y)$ & y(1)=1,y(1.1)=1.233, y(1.2) = 1.548,y(1.3) = 1.979. Evaluate y(1.4) by Adams Bash Fourth method
6. Employ Taylor's series method to find an approximate solution correct to fourth decimal places for the following initial value problem at x=0.1 & 0.2 $\frac{dy}{dx} = 2y + 3e^x$, y(0) = 0.
7. Using Milne's predictour corrector method find y where x=0.8 given $\frac{dy}{dx} = x - y^2$, y(0)=0, y(0.2)=0.02, y(0.4)=0.0795, y(0.6)=0.1762.Applying corrector formula twice.
8. Employ R-K method of 4rth order to solve the equation $\frac{dy}{dx} = 3x + y/2$, y(0)=1 at x=0.2 taking step length h=0.1
9. Solve the differential equation $\frac{dy}{dx} = x^2 + y^2$ given y(0)=1 to find the value of y(0.1) by using Taylor's series method of order.
10. Using modified Euler's method ,solve the equation $\frac{dy}{dx} = \frac{1}{x+y}$, y(0)=1 in steps of 0.5 at x = 1
11. Using Adams Bash fourth predictor correct method find y when x=0.8 given $\frac{dy}{dx} = x - y^2$, y(0)=0, y(0.2)=0.02, y(0.4)=0.0795, y(0.6)=0.1762. Apply correct formula twice.
12. Using Taylor's series method to find y at the point x=0.1& x=0.2 given that $\frac{dy}{dx} = x^2 + y^2$,y(0)=1
13. From the data given below find y at x=1.4 using Milne's predictour corrector method y'= x^2+y/2

x	1	1.1	1.2	1.3
y	2	2.2156	2.4649	2.7514

MODULE-5: Numerical Methods And Calculus Of Variation

1. Use R- K method to solve $y = xy'^2 - y^2$ for x = 0.2 correct to 4 decimal places. $y(0) = 1$ & $y'(0) = 0$
2. Evaluate $y(0.2)$ by RK method given that $y'' - x(y')^2 + y^2 = 0, y(0) = 1, y'(0) = 0$
3. Given $y'' - xy' - y = 0$ with the initial conditions y(0)=1, y'(0)=0. Compute y(0.2) and y'(0.2) by taking h=0.2 and using fourth order Runge Kutta method.
4. Obtain the solution of the equation $2\frac{d^2y}{dx^2} = 4x + \frac{dy}{dx}$ at the point x = 1.4 by applying Milne's method given that y(1) = 2, y(1.1) = 2.2156, y(1.2) = 2.4649. y(1.3) = 2.7514, $y'(1) = 2$, $y'(1.1) = 2.3178$, $y'(1.2) = 2.6725$ and $y'(1.3) = 3.0657$.
5. Using R-K method of order four, solve y" = y+xy', y(0) = 1 , y'(0) to find y(0.2) & y'(0.2).
6. Show that the Geodesics on a plane are straight line.
7. Find the Geodesics on a right circular cylinder of radius a.
8. Find the extremals of the functional $\int_{x_0}^{x_1} \frac{(y'^2)}{x^3} dx$
9. Show that the shortest distance between any two points in a plane is a straight line.
10. Prove that Catenary is the curve which when rotated about a line generates a surface of minimum area.
11. Find the extremal of the functional $\int_0^{\pi}(y'^2 - y^2 + 4y\cos x)dx$; $y(0) = 0 = y(\pi)$

12. Solve the variational problem $\delta \int_1^2 (x^2(y')^2 + 2y(x+y))dx = 0$, given $y(1) = y(2) = 0$
13. Find the path on which a particle in the absence of friction will slide from one point to another in a shortest time under the action of gravity.
14. Find the curve passing through the point (x_1, y_1) and (x_2, y_2) which when rotated about the x axis gives the minimum surface area.
15. Find the curve on which the functional $\int_0^1 (y'^2 + 12xy)\, dx$ with $y(0) = 0$ and $y(1) = 1$ can be extremised.

16.0 University Result

Examination	FCD (S+, S, A)	FC (B)	SC (C, D, E)	% Passing
Jan 2019				
Jan 2018	18	09	18	86.54

Prepared by		Checked by		
1) Prof. S.A.Patil	2) Prof. S. I. Shivamoggimath	Prof. S. L. Patil	**HOD**	**Principal**

Subject Title	MECHANICS OF MATERIALS		
Subject Code	18ME32	CIE Marks	40
Number of Lecture Hrs / Week	03(L)+02(T) 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:** 17/16
No. of times course taught: 08/08	**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. To know the different types of stresses and strains developed in the member subjected to axial, bending, shear, torsion & thermal loads.
2. To know behaviour & properties of engineering materials.
3. To understand the stresses developed in bars, compounds bars, beams, shafts, and cylinders.
4. To understand the concepts of calculation of shear force and bending moment for beams with different supports.
5. To expose the students to concepts of Buckling of columns and strain energy.

3.0 Course Outcomes

Having successfully completed this course, the student will be able to understand the,

CO	Course Outcome	Cognitive Level	POs
C302.1	Understand simple, compound, thermal stresses and strains their relations and strain energy.	L1,L2	PO1, PO2,PO3,PO4
C302.2	Analyze structural members for stresses, strains and deformations.	L1,L2 & L3	PO1, PO2,PO3,PO4
C302.3	Analyze the structural members subjected to bending and shear loads.	L1,L2 & L3	PO1, PO2,PO3,PO4
C302.4	Analyze shafts subjected to twisting loads.	L1,L2 & L3	PO1, PO2,PO3,PO4
C302.5	Analyze the short columns for stability.	L1,L2 & L3	PO1, PO2,PO3,PO4
Total Hours of instruction		**50**	

4.0 Course Content

Module - 1

Stresses and Strains: Introduction, Properties of materials, Stress, Strain and Hooke's law, Stress strain diagram for brittle and ductile materials, True stress and strain, Calculation of stresses in straight, Stepped and tapered sections, Composite sections, Stresses due to temperature change, Shear stress and strain, Lateral strain and Poisson's ratio, Elastic constants and relations between them. 10 hours

Module- 2

Analysis of Stress and Strain: Introduction to three dimensional state of stress, Stresses on inclined planes, Principal stresses and maximum shear stress, Principal angles, Shear stresses on principal planes, Maximum shear tress, Mohr circle for plane stress conditions.

Cylinders: Thin cylinder: Hoop's stress, maximum shear stress, circumferential and longitudinal strains, Thick cylinders: Lames equations. 10 hours

Module- 3

Shear Force and Bending Moment: Type of beams, Loads and reactions, Relationship between loads, shear forces and bending moments, Shear force and bending moments of cantilever beams, Pin support and roller supported beams subjected to concentrated loads, uniformly distributed constant / varying loads.

Stress in Beams: Bending and shear stress distribution in rectangular, I and T section beams. 10 hours

Module- 4

Theories of Failure: Maximum Principal stress theory, Maximum shear stress theory.

Torsion: Circular solid and hallow shafts, Torsional moment of resistance, Power transmission of straight and stepped shafts, Twist in shaft sections, Thin tubular sections, Thin walled sections 10 hours

Module- 5

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

Strain Energy: Strain energy due to axial, shear, bending, torsion and impact load. Castigliano's theorem I & II and their applications. 10 hours

5.0 Relevance to future subjects

Sl. No	Semester	Subject	Topics
01	VII/VIII	Project work	Fundamental concepts
02	VII	Dynamics of Machines	Fundamental concepts of vibrations and mechanical systems
03	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

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

Additional Study material & e-Books

1. Strength of Materials by R.K.Bansal_pdf drive
2. Strength of Materials by R.K.Rajaput_pdf drive

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

Website and Internet Contents References

1) Introduction to Strength of materials: https://www.youtube.com/watch?v=GkFgysZC4Vc
2) Solid Mechanics: https://www.youtube.com/watch?v=A1SWKe6ZwVc
3) Advanced strength of Materials: https://www.youtube.com/watch?v=_2d8YsXwm7M
4) Video on Torsion of circular shaft: https://www.youtube.com/watch?v=ICDZ5uLGrI4
5) Video on Bending of beam: https://www.youtube.com/watch?v=asBW0Ojc0bY
6) Video on deriving bending equation: https://www.youtube.com/watch?v=AvCkrU3KaZw
7) GATE: https://www.btechguru.com/GATE--mechanical-engineering--strength-of-materials-video-lecture--23--133.html
8) Theories of Failures: https://nptel.ac.in/courses/105102090/20
9) Columns:
   - https://www.youtube.com/watch?v=hwpGAxa8UoI&list=PL4K9r9dYCOoqADwI0zQXTJ6wy_Dr37Fy2
   - https://www.youtube.com/watch?v=F692spiIyHU&list=PL4K9r9dYCOoqADwI0zQXTJ6wy_Dr37Fy2&index=2
   - https://www.youtube.com/watch?v=DYeRXKa8mKA&list=PL4K9r9dYCOoqADwI0zQXTJ6wy_Dr37Fy2&index=3
   - https://www.youtube.com/watch?v=szApiRoy_wY&list=PL4K9r9dYCOoqADwI0zQXTJ6wy_Dr37Fy2&index=6
10) Strain Energy Theory
   - https://www.youtube.com/watch?v=szApiRoy_wY&list=PL4K9r9dYCOoqADwI0zQXTJ6wy_Dr37Fy2&index=6
   - https://www.youtube.com/watch?v=99_UsxPgDqs
   - https://www.youtube.com/watch?v=sur6mZ_66ak
   - https://www.youtube.com/watch?v=dX8hvaFczY4
   - https://www.youtube.com/watch?v=xf2UoWkIa5w
11) Gate solution with Key answers
   - www.iesacademy.com
   - https://www.iesacademy.com/uploaded_files/download/small-1465029586.pdf
   - https://www.youtube.com/watch?v=LF5GQNDVd7s&list=PLgzsL8klq6DI7pZwzHuLgpeQMLoTIGVgO
12) Stress Strain Theory at a Glance for IES & Gate
   https://www.iesacademy.com/uploaded_files/download/small-1463734449.pdf
13) Previous Question Papers:
   https://drive.google.com/file/d/1zdKzCsXBJWToiys54kv6pyXpWY6XMHYA/view

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	Concepts of stress and strain, Hooke's law and Mechanical Properties of Materials	
	3	Calculation of stresses and deformations in straight bar	
	4	Calculation of stresses and deformations in stepped bar	
	5	Calculation of stresses and deformations 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 elastic constants	
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	Flexural Formula for beams	
	29	Bending and Shear stress distributions in beams with rectangular, I, T, C cross-sections.	
	30	Problems on Bending and Shear stress distributions in beams	
Module-4	31	**Theories of Failures**	**80 %**
	32	Maximum principal stress theory	
	33	Maximum shear stress theory	
	34	Problems on Theories of Failures	
	35	**TORSION:** Torsion of solid circular and hallow shafts	
	36	Torsional Moment of Resistance	
	37	Power transmission of straight and stepped shafts	
	38	Twisting in shaft sections	
	39	Thin tubular and thin walled sections	
	40	Problems on Torsions	
Module-5	41	**Columns :**Buckling and Stability of columns, critical load	100%
	42	Analysis of columns with pinned ends and other support conditions	
	43	Effective length of columns	
	44	Secant formula	
	45	Problems on columns	
	46	**Strain Energy Theory**	
	47	Strain energy due to axial, shear, bending, torsion and impact load	
	48	Castigliano's theorem I &II	
	49	Load deformation diagram	
	50	Applications on Castigliano's theorem I &II	

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.

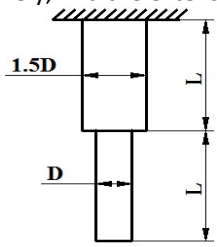
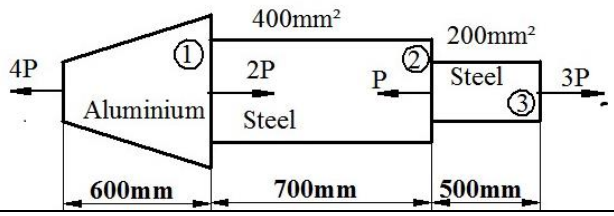


Figure 1

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.

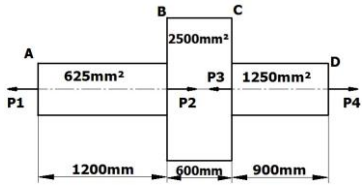


Figure 3

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)

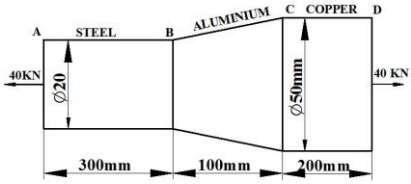


Figure 4

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.

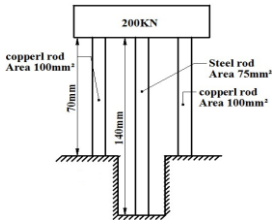


Figure 5

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, α_s=1.2x10^{-5}/˚C ,α_c=1.8x10^{-5}/˚C.

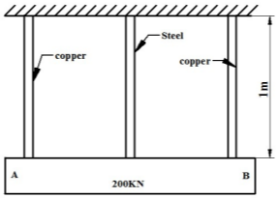


Figure 6

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 α_s=12x10^{-6}/˚C α_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 α_s=1.2x10^{-5}/˚C, αc=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

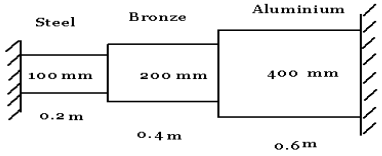


Figure 7

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.

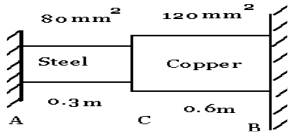


Figure 8

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.

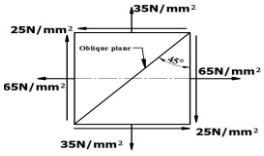


Figure 9

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

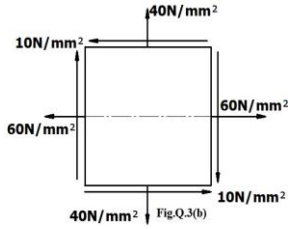


Figure 10

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)

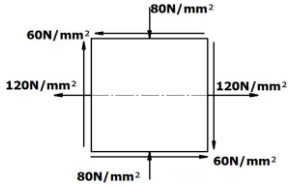


Figure 11

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

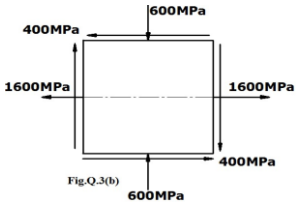


Figure 12

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.

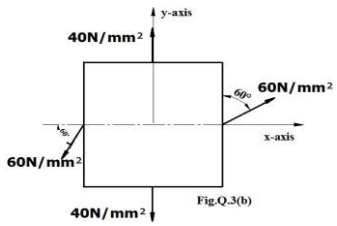


Figure 13

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

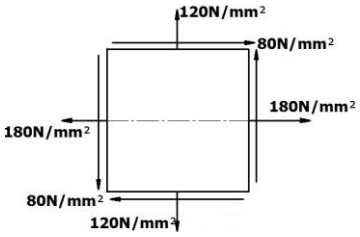


Figure 14

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.

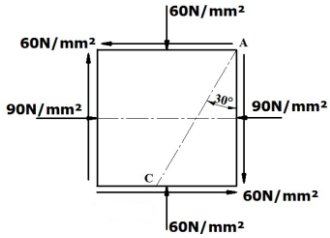


Figure15

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

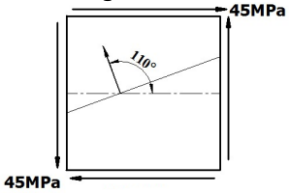


Figure 16

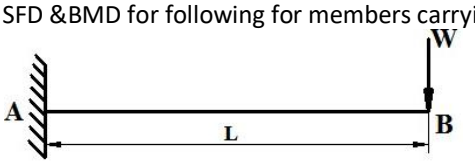
15. What is a thin cylinder and thick cylinder?
16. What do you understand by circumferential and longitudinal stresses?
17. Derive the expressions for the change in the dimensions of a cylinder subjected to internal pressure
18. Derive an expression for strain energy, when member subjected to impact 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 $\frac{Pd}{4tE}(5-4\mu)$, 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

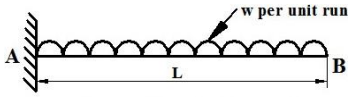
28. A thick cylinder with internal diameter 80mm and External diameter 120mm is subjected to an external pressure of 40Kn/m^2, when the internal pressure is 120KN/m^2 .Calculate the circumferential stress at external and internal surface of the cylinder. Plot the variation of circumferential stress and 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=2x10^5N/$mm^2$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:

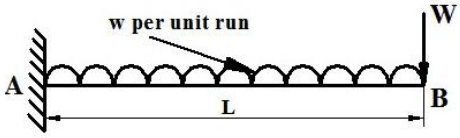
1. What are different types of beams? Explain briefly
2. What are different types of loads
3. Briefly explain different types of beam supports
4. Establish relationship between distriuted load, shear force and bending moment at a cross section of a beam
5. Define i)Shear force ii) Bending moment and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



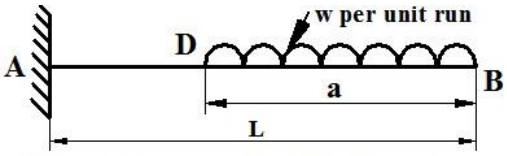
A cantilever of length L carrying a concentraed load w at free end



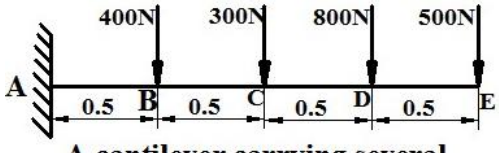
A cantilever of length L carrying a uniformly distributed load w per unit length over the whole length.



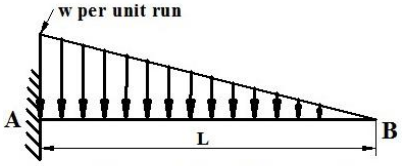
A cantilever of length L carrying a uniformly distributed load w per unit length over the whole length and acomcentrated load W at free end.



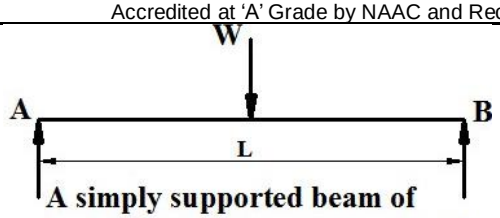
A cantilever of length L carrying a uniformly distributed load w per unit length for a distance 'a' from the free end.



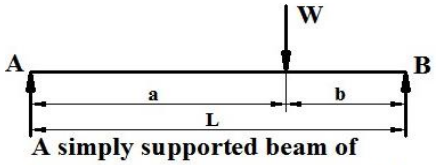
A cantilever carrying several concentraed loads.



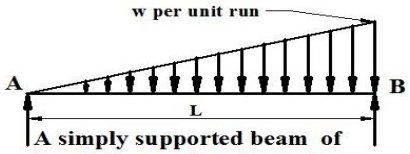
A cantilever of length L carrying a load whose intensity varies uniformly from zero at free end to w per unit run at fixed end.



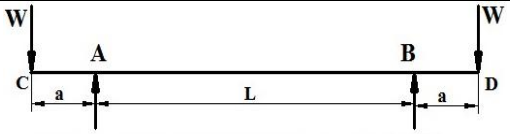
A simply supported beam of length L carrying a concentraed load w at mid span.



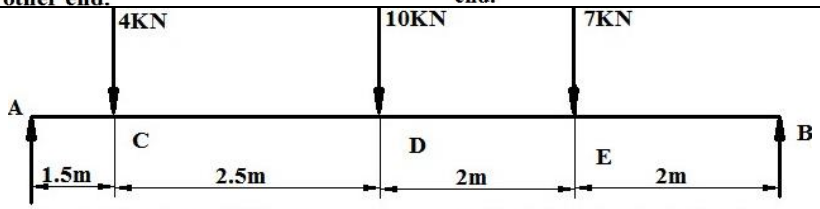
A simply supported beam of length L carrying a concentraed load w placed eccentrically on the span.



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.

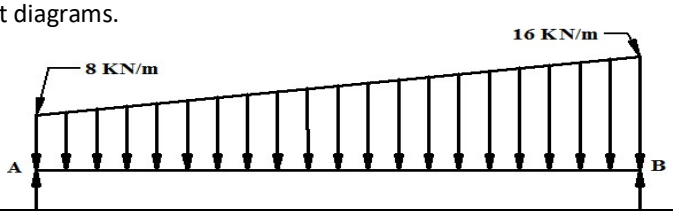


A beam of length (L+2a) has supports 'L' aparts with an overhang 'a' on each side. the beam carries a concentraed load w at each end.



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***

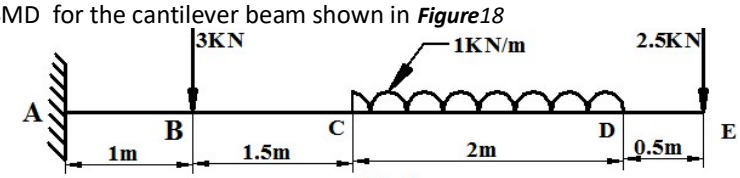


Figure18

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

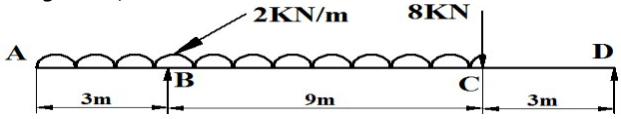


Figure 19

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

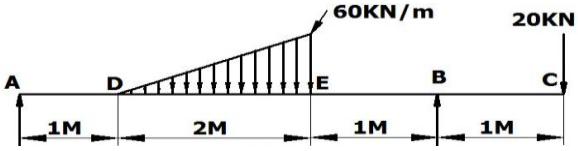


***Figure** 20*

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

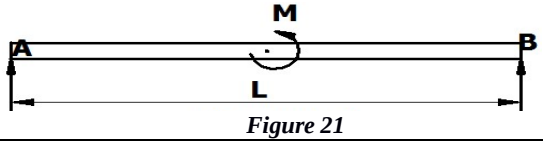


Figure 21

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

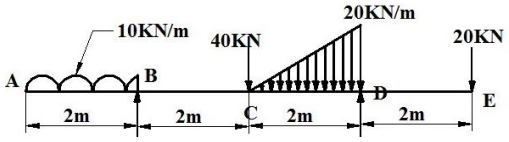


***Figure** 23*

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

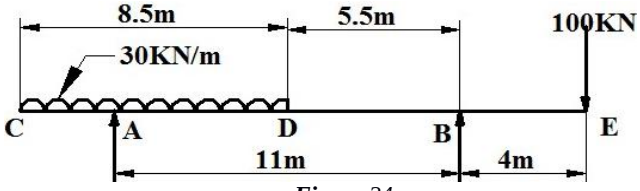


***Figure** 24*

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

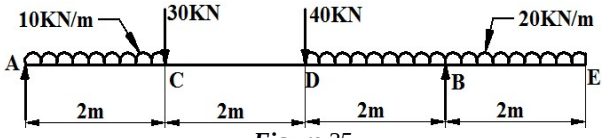


***Figure** 25*

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

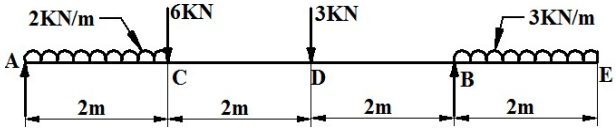


***Figure** 26*

16. 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

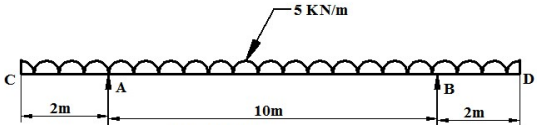


***Figure** 27*

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

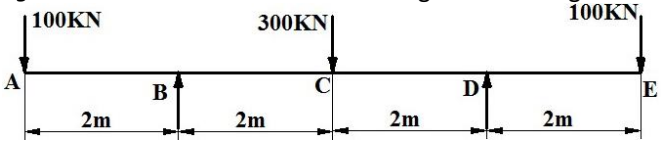


***Figure** 28*

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

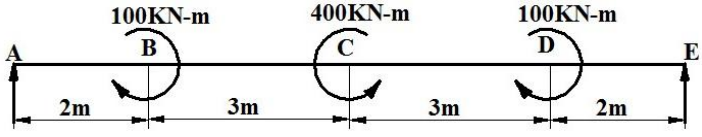


Figure *29*

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. An 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***).

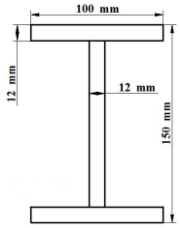


Figure 30

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.

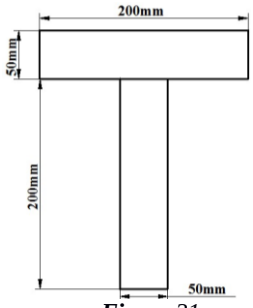


***Figure** 31*

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

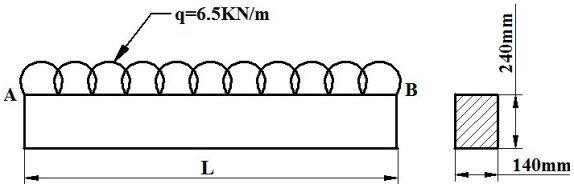


***Figure** 32*

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

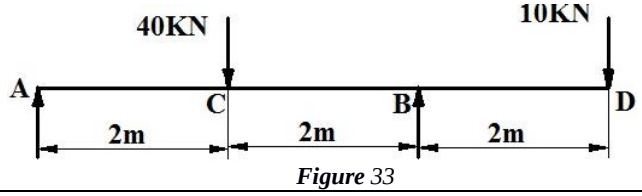


***Figure** 33*

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

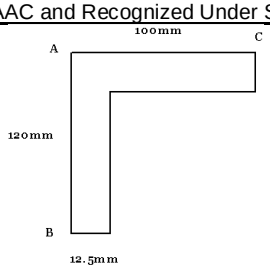


Figure 34

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.

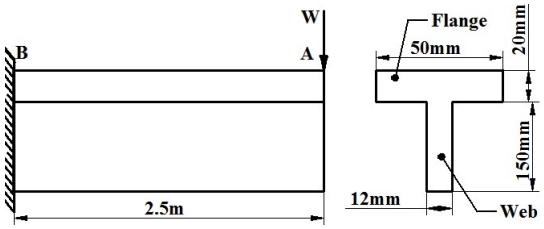


Figure 35

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.

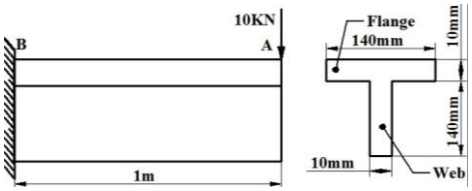


Figure 36

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.

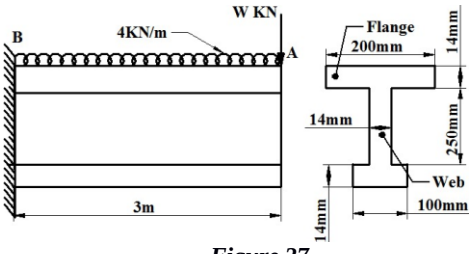


Figure 37

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.

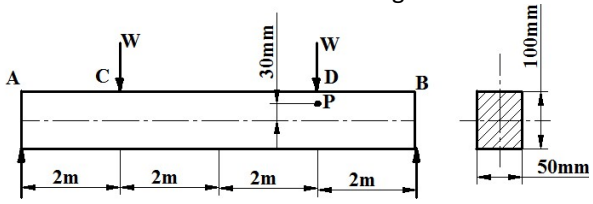


Figure 38

MODULE 4: Theories of Failure &TORSION

1. 1.Define the theories of failures and explain Maximum principal stress theory
2. 2. 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.

3.	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
4.	State the assumptions made in the theory of pure torsion
5.	Define Polar Modulus and Torsional rigidity
6.	Derive the torsion equation with usual notations. State the assumptions made in the derivation.
7.	Define a Column. What are different types of columns?
8.	What are the assumptions made in the theory of column?
9.	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
10.	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
11.	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.
12.	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

13.	A 2 meters long hollow cylinder shaft has 80mm outer diameter and 10mm wall thickness. When the tortional 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)
14.	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)
Module 5: COLUMNS & Strain Energy	
1.	Derive an expression for the critical load in a column subjected to compressive load
2.	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.
3.	Define slenderness ratio and derive Euler's expression for bucking load for column with both ends hinged
4.	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.
5.	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.
6.	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.
7.	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
8.	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
9.	Derive an expression for the critical load in a column subjected to compression load, when one end is fixed and the other end free.
10.	Derive an expression for the critical load in a column subjected to compression load, when one end is fixed and the other end free.
11.	Derive an expression for strain energy due to shear stresses
12.	Write a note on: (i) Maximum principal stress theory. (ii) Maximum shear stress theory
13.	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.
14.	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.
15.	Derive one expression for strain energy stored in an elastic bar when subjected to axial load, torque and bending moment.
16.	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.
17.	Define strain energy, Resilience, proof resilience and Modulus of resilience.
18.	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-18/Jan-19(A)	--	--	--	01	04	14	05	06	**80.00%**
Dec-18/Jan-19 (B)	--	--	01	02	06	06	16	12	**63.63%**

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

Subject Title	BASIC THERMODYNAMICS		
Subject Code	18ME33	CIA Marks	40
No of Lecture Hrs + Practical Hrs / Week	03	SEE Marks	60
Total No of Lecture + Practical Hrs	50	Exam Hours	03
			CREDITS – 03

FACULTY DETAILS:		
Name: Prof. K M Akkoli	**Designation:** Assistant. Professor	**Experience: 16** 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: 06		**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.
- Learn about thermodynamic system and its equilibrium
- Understand various forms of energy - heat transfer and work
- Study the basic laws of thermodynamics including, zeroth law, first law and second law.
- Interpret the behavior of pure substances and its application in practical problems.
- Study of Ideal and real gases and evaluation of thermodynamic properties

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 properties.	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

1. http://www.nptel.ac.in
2. 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

CIE : 40 Marks Assignment marks = 10
Internal Assessment Marks = 30
Semester End Examination: 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
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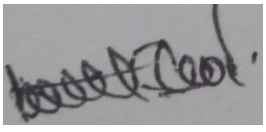
Prepared by	Checked by		
			
Prof. Jagadeesh A	**Prof. K M Akkoli**	**HOD**	**Principal**

Subject Title	**MATERIAL SCIENCE**		
Subject Code	18ME34	**CIE**	40
Number of Lecture Hrs / Week	03	**SEE**	60
Total Number of Lecture Hrs	40	**Exam Hours**	03
		CREDITS – 04	

FACULTY DETAILS:		
Name: Prof. K G Ambli	**Designation:** Asst. Professor	**Experience:** 07
No. of times course taught:04	**Specialization:** Product Design and Manufacturing	
Name: Prof.Mahantesh Tanodi	**Designation:** Asst.Professor	**Experience:**07
No. of times course taught:02	**Specialization:** Machine Design	

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

3.0 Course Outcomes

The student shall be able to;

1. **Understand the mechanical properties of metals and their alloys.**
2. Analyze the various modes of failure and understand the microstructures of ferrous and nonferrous materials
3. Describe the processes of heat treatment of various alloys.
4. Acquire the Knowledge of composite materials and their production process as well as applications.
5. Understand the properties and potentialities of various materials available and material selection procedures.

4.0 Course Content

MODULE 1

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

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

MODULE 2

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

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

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

Alloys, Steels, Solidification:

Concept of formation of alloys:Typesofalloys,solidsolutions,factorsaffectingsolidsolubility(HumeRotheryrules) **,Binary phasediagrams:Eutectic,andEutectoidsystems,Leverrule,Intermediatephases,(The same type of process will study in Iron Carbon Phase Diagrams) Gibbs phase rule, Effect of non-equilibrium cooling, Coring and Homo genization Iron-Carbon (Cementite) diagram: description of phases, Effect of common alloying elements in steel, Common alloy steels, Stainless steel, Tool steel, Specifications of steels. Solidification: Mechanism of solidification, Homogenous and Heterogeneous nucleation, Crystal growth, cast metal structures, Solidification of Steels and Cast irons. Numerical on Lever rule.**

MODULE 3

Heat Treatment, Ferrous and Non-Ferrous Alloys: Heat treating of metals: Time-TemperatureTransformation (TTT) curves, Continuous Cooling Transformation (CCT) curves, Annealing: Recovery, Re crystallization and Grain growth, Types of annealing, Normalizing, Hardening, Tempering, Mar tempering, Austempering, Concept of harden ability, Factors affecting harden ability. Surface hardening methods: carburizing, cyaniding, nit riding, flame hardening and induction hardening, Age hardening of aluminium-copper alloys and PH steels. Ferrous materials: Properties, Compositions and uses of Grey cast iron and steel.

MODULE 4

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

MODULE 5

Other Materials, Material Selection

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

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

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

Smart materials–fiber optic materials, piezo-electrics,shapememoryalloys–Nitinol,superelasticity. Biological applications of smart materials-materials usedasim plants in human Body, selection of materials, performance of materials in service. Residual life assessment–use of non-destructive testing, economics, environment and Sustainability.

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.
3. Shackle ford., & M. K. Muralidhara, Materials Science, 2007

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.
5. H. VanVlack, Elements of Materials Science and Engineering, 1998
6. Alan Cottrell, An introduction to Metallurgy 1974.

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

Question paper pattern:

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

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	Crystal imperfections–point, line, surface and volume imperfections.	
	3	Atomic Diffusion: Phenomen on, Fick's laws of diffusion (First and Second Law);Factors affecting diffusion.	
	4	**Mechanical Behaviour:** Stress-strain diagrams showing ductile and brittle behaviour of materials, Engineering stress and true strains,	
	5	Linear and non- linear elastic behaviour and properties,	
	6	Mechanical properties in plastic range: Stiffness, Yield strength, Offset Yield strength, Ductility, Ultimate Tensile strength, Toughness.	
	7	Plastic deformation of single crystal by slip and twinning, Mechanisms of strengthening in metals.	
	8	Problems	
2	9	**Failure of Materials Fracture:** Type I, Type II and Type III,	20%
	10	**Fatigue**: Types of fatigue loading with examples, Mechanism of fatigue, fatigue properties, S-N diagram, fatigue testing.	
	11	**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.	
	12	**Alloys, Steels, Solidification: Concept of formation of alloys**: Typesofalloys, solid solutions, factors affecting solidsolubility (HumeRotheryrules) ,	
	13	phase Binary diagrams: Eutectic, and Eutectoid systems, Leverrule, Intermediate phases, (The same type of process will study in Iron Carbon Phase Diagrams)	
	14	Gibbs phase rule, Effect of non-equilibrium cooling, Coring and Homo genization	
	15	Iron-Carbon (Cementite) diagram: description of phases, Effect of common alloying elements in steel, Common alloy steels, Stainless steel, Tool steel, Specifications of steels.	
	16	Solidification: Mechanism of solidification, Homogenous and Heterogeneous nucleation, Crystal growth, cast metal structures, Solidification of Steels and Cast irons. Numerical on Lever rule.	
3	17	**Heat Treatment, Ferrous and Non-Ferrous Alloys:** Heat treating of metals: Time-TemperatureTransformation (TTT) curves,Continuous Cooling Transformation (CCT) urves	20%
	18	Annealing: Recovery, Re crystallization and Grain growth, Types of annealing,	
	19	Normalizing, Hardening, Tempering, Mar tempering,	
	20	Austempering, Concept of harden ability, Factors affecting harden ability.	
	21	Surface hardening methods: carburizing, cyaniding, nitriding,	
	22	flame hardening and induction hardening, Age hardening of aluminium-copper alloys and PH steels.	
	23	Ferrous materials: Properties, Compositions and uses of Grey cast iron and steel.	
	24		
4	25	**Composite Materials :** Composite materials - Definition, classification, types of matrix materials & reinforcements, Metal Matrix Composites (MMCs),	20%
	26	Ceramic Matrix Composites (CMCs) and Polymer Matrix Composites (PMCs),	

	27	Particulate-reinforced and fiber- reinforced composites,	
	28	Fundamentals of production of composites, characterization of composites, constitutive relations of composites	
	29	determination of composite properties from component properties, hybrid composites.	
	30	Applications of composite materials.	
	31	Numerical on determining properties of composites.	
	32	Numerical on determining properties of composites.	
5	33	**Other Materials, Material Selection** **Ceramics:** Structure type sand properties and applications of ceramics. Mechanical/ Electrical behaviour and processing of Ceramics.	20%
	34	**Plastics:** Various types of polymers/plastics and their applications.	
	35	Mechanical behaviour and processing of plastics, Failure of plastics.	
	36	**Other materials:** Brief description of other materials such as optical and thermal materials.	
	37	**Smart materials–**fiber optic materials, piezo-electrics,shapememoryalloys–Nitinol,superelasticity.	
	38	Biological applications of smart materials-materials usedasim plants in human Body,	
	39	selection of materials, performance of materials in service.	
	40	Residual life assessment–use of non-destructive testing, economics, environment and Sustainability	

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

Faculty : K. G. Ambli M. I. Tanodi	Module coordinator	HOD	Principal

Subject Title	Metal Casting and Welding		
Subject Code	17ME35A	IA Marks	40
No of Lecture Hrs + Practical Hrs / Week	04	Exam Marks	60
Total No of Lecture + Practical Hrs	50	Exam Hours	03
CREDITS – 04			

FACULTY DETAILS:		
Name: Prof. S.R. Kulkarni	**Designation:** Asst. Professor	**Experience:**12 Years
No. of times course taught: 02	**Specialization:** Production Management	

1.0 Prerequisite Subjects:

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

2.0 Course Objectives

- To provide detailed information about the molding processes.
- To provide knowledge of various casting process in manufacturing.
- To impart knowledge of various joining process used in manufacturing.
- To provide adequate knowledge of quality test methods conducted on welded and casted components.

3.0 Course Outcomes

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

CO	Course Outcome	Cognitive Level	POs
C205.1	Classify manufacturing process and elaborate the parts of casting process.	U	1,6,12
C205.2	Summarize the different casting process and select the melting furnace based on ferrous and non-ferrous alloys.	U	1,6,12
C205.3	Understand the solidification, gasification, casting defects and different methods of directional solidification.	U	1,2,5,6,12
C205.4	List and explain different types of conventional welding processes.	U	1,2,3,6,12
C205.5	Explain different special types of welding, soldering, brazing and NDT.	U	1,2,3,5,6,12
Total Hours of instruction		**50**	

4.0 Course Content

MODULE -1

INTRODUCTION & BASIC MATERIALS USED IN FOUNDRY

Introduction: Definition, Classification of manufacturing processes. Metals cast in the foundry-classification, factors that determine the selection of a casting alloy.

Introduction to casting process & steps involved. Patterns: Definition, classification, materials used for pattern, various pattern allowances and their importance.

Sand molding: Types of base sand, requirement of base sand. Binder, Additives definition, need and types

Preparation of sand molds: Molding machines- Jolt type, squeeze type and Sand slinger. Study of important molding process: Green sand, core sand, dry sand, sweep mold, CO2 mold, shell mold, investment mold, plaster mold, cement bonded mold. Cores: Definition, need, types. Method of making cores, concept of gating (top, bottom, parting line, horn gate) and risering (open, blind) Functions and types. **10 Hours**

MODULE -2

MELTING & METAL MOLD CASTING METHODS

Melting furnaces: Classification of furnaces, Gas fired pit furnace, Resistance furnace, Coreless induction furnace, electric arc furnace, constructional features & working principle of cupola furnace.

Casting using metal molds: Gravity die casting, pressure die casting, centrifugal casting, squeeze casting, slush casting, thixocasting, and continuous casting processes. **10 Hours**

MODULE -3

SOLIDIFICATION & NON FERROUS FOUNDRY PRACTICE

Solidification: Definition, Nucleation, solidification variables, Directional solidification-need and methods. Degasification in liquid metals-Sources of gas, degasification methods.

Fettling and cleaning of castings: Basic steps involved. Sand Casting defects- causes, features and remedies. Advantages & limitations of casting process

Nonferrous foundry practice: Aluminum castings - Advantages, limitations, melting of aluminum using lift-out type crucible furnace. Hardeners used, drossing, gas absorption, fluxing and flushing, grain refining, pouring temperature. Stir casting set up, procedure, uses, advantages and limitations. **10 Hours**

MODULE -4

WELDING PROCESS

Welding process: Definition, Principles, Classification, Application, Advantages & limitations of welding. Arc welding: Principle, Metal arc welding (MAW), Flux Shielded Metal Arc Welding (FSMAW), Inert Gas Welding (TIG & MIG) Submerged Arc Welding (SAW) and Atomic Hydrogen Welding (AHW).

Special type of welding: Resistance welding principles, Seam welding, Butt welding, Spot welding and Projection welding. Friction welding, Explosive welding, Thermit welding, Laser welding and electron beam welding.**10 Hours**

MODULE -5

SOLDERING, BRAZING AND METALLURGICAL ASPECTS IN WELDING

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

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

Inspection methods: Methods used for inspection of casting and welding. Visual, magnetic particle, fluorescent particle, ultrasonic, Radiography, eddy current, holography methods of inspection. **10 Hours**

5.0 Relevance to future subjects/Area

SL. No	Semester	Subject	Topics / Relevance
01	V	Non Traditional Machining	Industry

6.0 Relevance to Real World

SL. No	Real World Mapping
01	Casting Processes and testing
02	Melting Furnaces
03	Metal joining Techniques and Testing

7.0 Books Used and Recommended to Students

Text Books

1. "Manufacturing Process-I", Dr.K.Radhakrishna, Sapna Book House, 5th Revised Edition 2009.
2. "Manufacturing & Technology: Foundry Forming and Welding", P.N.Rao, 3rd Ed., Tata McGraw Hill, 2003.

Reference Books
1. "Process and Materials of Manufacturing", Roy A Lindberg, 4th Ed.Pearson Edu. 2006. 2. "Manufacturing Technology", SeropeKalpakjian, Steuen. R. Sechmid, Pearson Education Asia, 5th Ed. 2006. 3. "Principles of metal casting", Rechard W. Heine, Carl R. LoperJr., Philip C. Rosenthal, Tata McGraw Hill Education Private Limited Ed.1976.
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
3. http://www.nptel.ac.in
4. http://me.emu.edu.tr/me364/2.pdf
5. http://www.weldingtypes.net/

9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	Global Casting Magazines	http://www.globalcastingmagazine.com/
2	Science Direct	http://www.sciencedirect.com

10.0 Examination Note

- The question paper will have ten questions.
- Each full question consisting of 20 marks.
- There will be 2 full questions (with a maximum of 4 sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

11.0 Course Delivery Plan

Module	Lecture No.	Content of Lecturer	% of Portion
1	1	Definition, Classification of manufacturing processes. Metals cast in the foundry-classification	20%
	2	Factors that determine the selection of a casting alloy. Introduction to casting process & steps involved.	
	3	Patterns: Definition, classification, materials used for pattern, various pattern allowances and their importance.	
	4	Sand molding: Types of base sand, requirement of base sand. Binder, Additives definition, need and types.	
	5	Preparation of sand molds: Molding machines- Jolt type, squeeze type and Sand slinger.	
	6	Study of important molding process: Green sand, core sand,	
	7	Dry sand, sweep mold, CO2 mold, shell mold, investment mold, plaster mold, cement bonded mold..	
	8	Cores: Definition, need, types. Method of making cores,	

	9	concept of gating (top, bottom, parting line, horn gate)	
	10	Risering (open, blind) Functions and types	
2	11	Melting furnaces: Classification of furnaces,	40%
	12	Gas fired pit furnace, Resistance furnace,	
	13	Coreless induction furnace, electric arc furnace,	
	14	Constructional features & working principle of cupola furnace.	
	15	Casting using metal molds: Gravity die casting,	
	16	Pressure die casting,	
	17	Centrifugal casting,	
	18	Squeeze casting,	
	19	Slush casting,	
	20	Thixocasting, continuous casting processes	
3	21	Solidification: Definition, Nucleation, solidification variables,	60%
	22	Directional solidification-need and methods. Degasification in liquid metals-Sources of gas, degasification methods	
	23	Fettling and cleaning of castings: Basic steps involved.	
	24	Sand Casting defects- causes, features and remedies	
	25	Advantages & limitations of casting process	
	26	Nonferrous foundry practice: Aluminum castings - Advantages, limitations,	
	27	Melting of aluminum using lift-out type crucible furnace.	
	28	Hardeners used, drossing, gas absorption,	
	29	Fluxing and flushing, grain refining, pouring temperature.	
	30	Stir casting set up, procedure, uses, advantages and limitations	
4	31	Welding process: Definition, Principles, Classification,	80%
	32	Application, Advantages & limitations of welding. Arc welding:	
	33	Principle, Metal arc welding (MAW), Flux Shielded Metal Arc Welding (FSMAW),	
	34	Inert Gas Welding (TIG & MIG)	
	35	Submerged Arc Welding (SAW) and Atomic Hydrogen Welding (AHW).	
	36	Special type of welding: Resistance welding principles,	
	37	Seam welding, Butt welding,	
	38	Spot welding and Projection welding.	
	39	Friction welding, Explosive welding,	
	40	Thermit welding, Laser welding and electron beam welding.	
5	41	Soldering, Brazing And Metallurgical Aspects In Welding Structure of welds, Formation of different zones during welding,	100%
	42	Heat Affected Zone (HAZ), Parameters affecting HAZ.	
	43	Effect of carbon content on structure and properties of steel, Shrinkage in welds& Residual stresses.	
	44	Concept of electrodes, filler rod and fluxes.	
	45	Welding defects- Detection, causes & remedy	
	46	Soldering, brazing, gas welding: Soldering, Brazing,	
	47	Gas Welding: Principle, oxy-Acetylene welding, oxy-hydrogen welding, air-acetylene welding, Gas cutting, powder cutting.	
	48	Inspection methods: Methods used for inspection of casting and welding.	
	49	Visual, magnetic particle, fluorescent particle,	
	50	ultrasonic, Radiography, eddy current, holography methods of inspection	

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: University Questions	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 1 syllabus	3	Individual Activity and submission of hard copy.	Book 1 and all the reference book
2	Assignment 2: University Questions	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 2 syllabus	6	Individual Activity and submission of hard copy.	Book 1 and all the reference book
3	Assignment 3: University Questions	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 3 syllabus	9	Individual Activity and submission of hard copy.	Book 1 and all the reference book
4	Assignment 3: University Questions	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 4 syllabus	12	Individual Activity and submission of hard copy.	Book 1 and all the reference book
5	Assignment 3: University Questions	Students study the Topics and write the Answers. Get practice to solve university questions.	Module 5 syllabus	15	Individual Activity and submission of hard copy.	Book 1 and all the reference book

13.0 QUESTION BANK

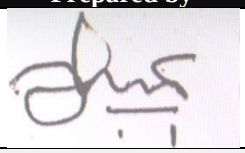
Sample Questions	Questions
VI	**MODULE 1** 1. Define casting. Enumerate different steps involved in producing a component by casting process. 2. Mention the advantages of casting in comparison with other manufacturing processes. 3. Explain the terms pattern, core, mould and casting in casting process. 4. With neat sketches explain different types of patterns and mention their applications 5. Define a pattern. Differentiate between a casting and pattern. 6. What are the common materials used for pattern making? Discuss their relative merits and demerits. 7. What are the factors which govern the selection of a proper material for pattern making? 8. Enumerate and briefly explain various pattern allowances. 9. Define a pattern. Differentiate between a casting and pattern. 10. What are the common materials used for pattern making? Discuss their relative merits and demerits. 11. What are the factors which govern the selection of a proper material for pattern

	making? 12. Enumerate and briefly explain various pattern allowances. 13. Explain match plate pattern with sketch. 14. Write explanatory note on no bake sands. 15. Sketch and exlain sand slinger machine. 16. With neat sketch explain shell moulding process. 17. Draw gating system and show all the elements. 18. Explain cement bonded mould 19. Explain method of making core 20. Discuss functions and types of gating system.
VII	**MODULE 2** 1. Mention the factors to be considered in the selection of a suitable melting furnace. 2. What are the different types of crucible furnaces? With a sketch explain the principle of operation of a gas fired pit furnace. 3. With a sketch explain the operation of a high frequency induction furnace. 4. What are the differences between core type and coreless type induction furnaces? 5. With a neat sketch explain the operation of an indirect arc furnace. How does it differ from a direct arc furnace? 6. With a neat sketch explain the operation of cupola furnace. 7. Draw the neat sketch of a cupola showing the constructional details. Mark the different zones clearly and discuss the importance of each zone. 8. Draw a simple sketch and write a brief note on cupola charge. 9. Write the different reactions taking place in various zones of a cupola. 10. With neat sketch explain constructional and working features of electrical resistance furnace.
VIII	**MODULE 3** 1. Define solidification process; explain with sketches solidification of pure metals. 2. Explain nucleation – homogeneous nucleation, heterogeneous nucleation. 3. What is degassing, explain the need. 4. What are the methods for degassing? 5. Explain sources of degassing in liquid metals. 6. What is fettling & explain basic steps involved in cleaning of casting? 7. Explain aluminum casting. 8. How casting defects are are classified? 9. Explain the advantages and disadvantages of aluminum castings. 10. Explain drossing gas absorption.
IX	**MODULE 4** 1. What is the working principle of arc welding? 2. Explain clearly the functions of flux in welding 3. Explain straight polarity and reverse polarity 4. Write a note on the classification of electrodes 5. Write a brief note on weld pattern used in arc welding 6. Explain with a neat sketch submerged arc welding process, mentioning its advantages and limitations. 7. Explain with a neat sketch flux-cored arc welding process, and bring out its advantages and limitations. 8. What is inert gas welding? Explain with a neat sketch the TIG welding process. Mention its advantages and limitations. 9. How is the MIG welding different from the TIG welding? Explain. 10. Briefly explain the atomic hydrogen welding process. 11. With a neat sketch explain the principle, process and applications of plasma arc welding process. 12. Differentiate between soldering and brazing.
X	**MODULE 5** 1. Define weld ability. Classify different welding tests. 2. What is weld ability? How is it assessed? Explain.

	3. Briefly explain the factors that affect the weld ability of materials. 4. Draw a neat sketch to show the various regions (zones) of a welded joint, along with the grain structure. 5. With a neat sketch explain the metallurgical aspects of welding highlighting changes in the structure of the weld at different zones. 6. What process of welding would you recommend for welding (i) cast iron, (ii) steel 7. With a neat sketch explain the solidification of the weld and the resulting structure of the low carbon steel. 8. Write notes on: (i) solidification of the weld. (ii) HAZ in the weld 9. What is NDT? Give a brief classification of NDT methods. 10. With a neat sketch explain the various steps involved in the liquid dye penetrant testing of components & list the advantages and applications. 11. With a neat sketch explain the x-ray radiographic inspection method. Also list its advantages and disadvantages? 12. Briefly explain x-ray radiographic technique of non-destructive testing. 13. With a neat sketch explain the ultrasonic inspection for castings. Also list its advantages, disadvantages and applications. 14. With a neat sketch explain the magnetic inspection method. What are its advantages and disadvantages? 15. With a neat sketch explain the eddy current inspection method. What are its limitations and applications? 16. With a neat sketch explain the holographic inspection method. What are the applications?

14.0 University Result

Examination	S+	S	A	B	C	D	E	F	% Passing
Jan 2018-19	-	-	02	10	8	8	2	0	100

Prepared by	Checked by		
			
Prof. S. R. Kulkarni	Prof. G A Naik	HOD	Principal

Subject Title	**MECHANICAL MEASUREMENTS AND METROLOGY**		
Subject Code	18 ME 36 B	**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:07	**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

6. http://www.tatynerds.com/mechanical-metrology-metrology
7. http: //www.vturesource.com/2011/01/mechanical-measurements
8. http://www.nptel.ac.in
9. 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)
(c) 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	51	Definition, objectives and concept of metrology	20%
	52	Need of inspection, Principles, process,	
	53	methods of measurement, Classification and selection of measuring instruments and systems	
	54	Accuracy, precision and errors in measurement	
	55	System of measurement, Material Standard, Wavelength Standards, Subdivision of standards,	
	56	Line and End standards, Classification of standards and Traceability, calibration of End bars(Numerical), standardization	
	57	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,	
	58	care of slip gauge, slip gauge accessories, problems on building of slip gauges (M87, M112) Auto collimator-applications for measuring straightness and squareness	
2	59	Definition of tolerance, Specification in assembly, Principle of interchangeability and selective assembly	40%
	60	limits of size, Indian standards, concept of limits of size and tolerances,	
	61	definition of fits, hole basis system, shaft basis system, types of fits and their designation (IS 919-1963),	
	62	Geometric tolerance, position-tolerances. Classification of gauges, brief concept of design of gauges (Taylor's principles),	
	63	Wear allowance on gauges, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials.	
	64	Functional requirements, classification	
	65	mechanical- Johnson Mikrokator, sigma comparators	
	66	dial indicator, electrical principles, , LVDT, Pneumatic- back pressure gauges, solex comparators optical comparators- Zeiss ultra-optimeter	
3	67	Terminology of screw threads, measurement of major diameter	60%
	68	minor diameter, pitch, angle and effective diameter of screw threads by 2-wire and 3- wire methods,	

	69	best size wire. Screw thread gauges, Tool maker's microscope. Gear tooth terminology, tooth thickness measurement using constant chord method,	
	70	addendum comparator method and base tangent method, measurement of pitch	
	71	Concentricity, run out, and involute profile. Gear roll tester for composite error	
	72	Basic concepts of lasers, advantages of lasers	
	73	laser interferometers, types	
	74	applications. Basic concepts of Coordinate Measuring Machines constructional features, applications, constructional features, applications	
4	75	Definition, significance of measurement, generalized measurement system	80%
	76	definitions and concept of accuracy, precision, calibration,	
	77	threshold, sensitivity, hysteresis, repeatability, linearity, loading effect, system response-time delay. Errors in measurement,	
	78	Classification of errors. Transducers, transfer efficiency, primary and secondary transducers,	
	79	Mechanical, electronic transducers, advantages of each type transducers.	
	80	Mechanical systems, inherent problems	
	81	electrical intermediate modifying devices	
	82	input circuitry, ballast circuit, Electronic amplifiers. Terminating devices Cathode ray oscilloscope, Oscillographs	
5	83	Direct methods and indirect method	100%
	84	force measuring inst. Torque measuring inst., Types of dynamometers, Absorption dynamometer	
	85	Prony brake and rope brake dynamometer, and power measuring instruments.	
	86	Pressure measurement, principle, use of elastic members	
	87	Bridgeman gauge, McLeod gauge, Pirani gauge.	
	88	Theory of strain gauges, types, electrical resistance strain gauge, preparation and mounting of strain gauges,	
	89	Gauge factor, methods of strain measurement. Temperature Compensation, Wheatstone bridge circuit,	
	90	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 in metrology	Describe different Measurement of screw thread and gear and advances in Metrology	Module 3	6	Individual Activity..	Text Book 2
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 Wringing phenomenon

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 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.

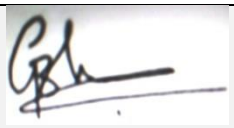
Module V

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
July 2019	00	00	13	32	19	04	04	96.85

 **Faculty 1:B .M. Dodamani**	 **HOD**	 **Principal**

Subject Title	Mechanical measurements and Metrology Laboratory		
Subject Code	17MEL37B / 47B	**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. S R Kulkarni	**Designation:** Asst. Professor	**Experience:**12Years
No. of times course taught: 01 Time	**Specialization:** Production Management	

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

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
4. 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
10. http://www.tatynerds.com/mechanical-metrology-metrology
11. http: //www.vturesource.com/2011/01/mechanical-measurements
12. http://www.nptel.ac.in
13. 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)

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

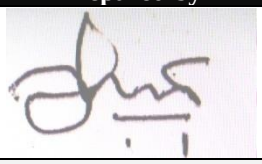
9	9	To determine strain of a cantilever beam (AL) using strain gauges	
10	10	Measurement of effective diameter of screw thread using three-wire method	
11	11	To measure width & height of gear tooth at pitch circle diameter of a given gear.	
12	12	Calibration of LVDT with respect to micrometer by spring 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	S+	S	A	B	C	D	E	F	% Passing
Feb 2018-19	25	7	3	-		-	-	-	100
Feb 2017-18	30	15	15	5	-	-	-	-	100

Prepared by	Checked by		
			
Prof. S R. Kulkarni	Prof. G A Naik	HOD	Principal

Subject Title	FOUNDRY AND FORGING LABORATORY		
Subject Code	18MEL 38B/ 48B	IA Marks	40
No of Lecture Hrs + Practical Hrs / Week	01+02	Exam Marks	100 (60)
Total No of Lecture + Practical Hrs	52	Exam Hours	03
CREDITS – 02			

FACULTY DETAILS:		
Name: Prof. M S Futane	**Designation:** Asst. Professor	**Experience:** 15Years
No. of times course taught: 04 Times	**Specialization:** CIM	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
01	Mechanical Engineering	I	Elements of Mech Engineering
02	Mechanical Engineering	III / IV	Metal Casting and Welding
03	Mechanical Engineering	III / IV	Manufacturing Process II

2.0 Course Objectives

- To provide an insight into different sand preparation and foundry equipments.
- To provide an insight into different forging tools and equipments.
- To provide training to students to enhance their practical skills.
- To practically demonstrate precautions to be taken during casting and hot working.
- To develop team qualities and ethical principles.

3.0 Course Outcomes

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

CO	Course Outcome	Cognitive Level	POs
C208.1	Demonstrate the applications of basic of Foundry and Forging processes.	L2	1,2,12
C208.2	Experiment with molding sand to determine tensile, compression and Shear	L3	1,2,3,4,5,6,8,12
C208.3	Evaluate the sand properties by conducting permeability, clay content and	L5	1,2,3,4,5,6,8,12
C208.4	Apply sand molding process through preparation of moulds using two molding	L3,L6	1,2,3,4,6,8,12
C208.5	Determine the length of the raw material required and create the forging	L5,L6	1,2,3,4,5,6,8,12
Total Hours of instruction		**52**	

4.0 Course Content

PART A

1 **Testing of Molding sand and Core sand.**

Preparation of sand specimens and conduction of the following tests:

1. Compression, Shear and Tensile tests on Universal Sand Testing Machine.
2. Permeability test
3. Sieve Analysis to find Grain Fineness Number (GFN) of Base Sand
4. Clay content determination on Base Sand.

Welding Practice:

Use of Arc welding tools and welding equipment

Preparation of welded joints using Arc Welding equipment

L-Joint, T-Joint, Butt joint, V-Joint, Lap joints on M.S. flats

PART B

2 **Foundry Practice:**
Use of foundry tools and other equipment for Preparation of molding sand mixture.
Preparation of green sand molds kept ready for pouring in the following cases:
1. Using two molding boxes (hand cut molds).
2. Using patterns (Single piece pattern and Split pattern).
3. Incorporating core in the mold.(Core boxes).
4. Preparation of one casting (Aluminium or cast iron-Demonstration only)

PART C

3 **Forging Operations:** Use of forging tools and other forging equipment.
• Calculation of length of the raw material required to prepare the model considering scale loss.
• Preparing minimum three forged models involving upsetting, drawing and bending operations.

5.0 Relevance to future subjects

SL. No	Semester	Subject	Topics / Relevance
01	III / IV	Machine Shop Lab	Provides basics of materials 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	Casting of raw material in to variety components by foundry process
02	Forming of components for various applications by forging and welding process

7.0 Books Used and Recommended to Students

Text Books
1. Workshop Technology by Hazra Chaudhary vol I & vol II.
2. A Textbook of Foundry Technology eBook By O P Khanna PDF.
Reference Books
1. Fundamentals of Metal Forming by Robert Wagoner
2. Green sand Casting by Lindsay Publications
Additional Study material & e-Books

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

Website and Internet Contents References
1. http://www.foundrymagazineindia.com 2. http://foundrymag.com.
3. http://www.foundrytradejournal.com/ 4.http://www.nptel.ac.in

9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	Website
1	Indian Foundry Journal	www.indianfoundry.org/indian-foundry-journal.php
2	International Journal of Metalcasting | AFS - American Foundry Society	www.afsinc.org › Technical & Management › International Journal of Metalcasting
3	International Journal of Metalcasting - Springer	www.springer.com › Home › Materials › Special types of Materials

4	Metal, Metallurgy & Foundry Periodicals, Magazines, Journals	www.castingarea.com/research/magazines.htm

10.0 Examination Note

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

11.0 Course Delivery Plan

Expt No	Lecture /Practical No	Name of the Experiment	% Of Portion
1	1	Introduction to Sand Preparation experiments.	47.61
2	2	To conduct an experiment to find out the compression strength of given sand specimen	
3	3	To conduct shear strength test on a standard sand test specimen and to derive the results.	
4	4	To determine the permeability number of given green sand specimen.	
5	5	To find the grain fine number of given sand sample .	
6	6	To determine percentage of clay in the given sand sample	
7	7	Introduction to Foundry, forging & welding and tools details	
8	8	To cut an ellipse of given dimensions.	26.19
9	9	To make a hexagonal and square cavity as per sketch.	
10	10	To make equilateral triangle core in a circle	
11	11	To make the square bar from round bar of 10mm dia.	
12	12	To make eye hook from round bar of 10 mm dia.	26.19
13	13	To make round headed bolt from round bar of 12 mm dia.	
14	14	To prepare L & T type welded joint	
15	15	To prepare Lap & Butt welding joint	

12.0 Question Bank

1. List the characteristics of Foundry sand.
2. Explain Refractoriness of foundry sand?
3. Define Permeability of foundry sand.
4. What do you mean by Flow ability or plasticity
5. What is Adhesiveness of foundry sand?
6. Define Cohesiveness of foundry sand?
7. What is collapsibility of foundry sand?
8. What is Green sand?
9. What is Dry sand?
10. What is the use of Facing sand?
11. What is Parting sand?
12. What do you mean by Baking sand?
13. What is Core sand?
14. What is Molasses sand?
15. Mention the advantage of Molasses sand.
16. Which sand is called as Fat sand?
17. What is the effect of sand grains on foundry sand?
18. Mention the types of sand grain surfaces.
19. Why the Smooth sand grain surface is preferred?
20. What are the different shapes of sand grains?
21. For light castings which type of foundry san d is preferred?
22. For bench work which type of foundry sand is preferred?
23. For large iron and steel castings which type of foundry sand is used?
24. What is the purpose of adding Binders to the foundry sand?
25. Name the common binders used in foundry?
26. List the commonly used Organic binders.
27. List the commonly used inorganic binders
28. Which is the most widely used inorganic binders?
29. What are Additives related to foundry?
30. List commonly used Additives.
31. Where Coal dust additives are used?
32. Mention the main purpose of using coal dust additives?
33. What is Sea coal?
34. What is the nature of Sea coal?
35. What are Pitch additives?
36. What is the role of Water on foundry sand?
37. Mention the quantity of water added to foundry sand.
38. What necessitates testing Foundry sand?
39. Name the Sand testing Equipments used in foundry laboratory.
40. Name the commonly performed tests on foundry test.
41. Why Grain fineness test is conducted?
42. Mention the methods used to test grain fineness?
43. Why Moisture content test is necessary?

13.0 University Result

Examination	FCD	FC	SC	% Passing
Jan 2018-19	61	0	0	100
Jan 2016-17	6	1	1	100

Prepared By	Checked By		
Mr .M. S Futane	G. A Naik	HOD	Principal