Department of Mechanical Engineering

COURSE PLAN 2019-20

IV Semester "A" 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.

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Theory Course Plan			
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2	Applied Thermodynamics	18ME42	9-18
3	Fluid Mechanics	18ME43	19-27
4	Kinematics of Machines	18ME44	28-37
5	Metal Casting and Welding	18ME45B	38-44
6	Mechanical measurements and metrology	18ME46B	45-54
Laboratory – Course Plan and Viva Questions			
7	Mechanical measurements and metrology Lab.	18ME47B	55-58
8	Foundry ,Forging and Welding	18ME48B	59-62

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. G A Naik(IV A)	Sri. M S Kurani
		Prof. M A Hipparagi (IV B)	Sri. R B Kumbar
		Prof. M. M. Shivashimpi (VI A)	Sri. R M Hunchyali
		Prof. T S Vandali (VI B)	Sri. S R Nakadi
		Prof. S. B. Awade (VIII A)	Sri. S C Jotawar
		Prof. A M Biradar (VIII 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. Nakadi
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. Akkole (9480422508)	
03	Hostel warden KSCST Coordinator	Prof. M S Futane (7829611609)	
04	AICTE/ Hostel Asst. Warden Coordinator	Dr. 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	Dr. 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	775916.75
3	Energy Conversion Engg. Laboratory	173	1273803.2
4	Machine shop Laboratory	170	1372566.5
5	Foundry & Forging Laboratory	179	318787.11
6	Design Laboratory	73	365861.00
7	Heat & Mass Transfer Laboratory	148	524576
8	Material Testing Laboratory	149	1102945.2
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	1437796.3
13	Department/Other	--	2025039.2
	Total	**1527**	**15907370.61**

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	27	9480849331
2	Dr. S. A. Alur	Professor	Ph. D	Thermal Power Engg.	LMISTE	--	25	9686856029
3	Dr. B M Shrigiri	HOD/Professor	Ph. D	Thermal Power Engg.	LMISTE	01	21	9741483339
4	Dr. S. N. Topannavar	Assoc. Professor	M Tech.(Ph. D)	Thermal Power Engg.	LMISTE	01	19	9482440235
5	Prof. D. N. Inamdar	Asso. Professor	M Tech.(Ph. D)	Tool Engg	LMISTE	08	15	9591208980
6	Dr. K. M. Akkoli	Asso. Professor	M Tech.(Ph. D)	Thermal Power Engg.	LMISTE	1.5	15	9739114856
7	Prof. R.K.Chitgopkar	Asst. Professor	M Tech.	Thermal Power Engg.	LMISTE	1.5	27	9886070475
8	Prof.G. A. Naik	Asst. Professor	M Tech.	Production Management	LMISTE	02	22	9480539283
9	Prof. G. V. Chiniwalar	Asst. Professor	M Tech.	Machine Design	LMISTE	04	15	8762336434
10	Prof.M.S.Futane	Asst. Professor	M Tech.	Computer Integrated Manufacturing	LMISTE	01	13	9164105035
11	Prof. T. S. Vandali	Asst. Professor	M Tech.	Machine Design	LMISTE	8.5	09	9686235904
12	Prof.S. A. Goudadi	Asst. Professor	M Tech.	Design Engineering	LMISTE	--	11	9448876682
13	Sri. S.R. Kulkarni	Asst. Professor	M Tech.	Design Engineering	LMISTE	--	11	8123661692
14	Prof.M.M.Shivashimpi	Asst. Professor	M Tech.(Ph.D)	Thermal Power Engg.	LMISTE	01	09	9742197173
15	Prof. M.A.Hipparagi	Asst. Professor	M Tech.(Ph.D)	Production Technology	LMISTE	02	08	7411507405
16	Prof. A. M. Biradar	Asst. Professor	M Tech.	Machine Design	LMISTE	02	08	9986127703
17	Prof. K. G. Ambli	Asst. Professor	M Tech.(Ph.D)	Product Design and Manufacturing	LMISTE	0.8	07	9164534514
18	Prof. S. B. Awade	Asst. Professor	M Tech.	Machine design	LMISTE		06	9632606108
19	Prof.Mahantesh Tanodi	Asst. Professor	M Tech.	Machine design	LMISTE	--	07	9611998812
20	Prof. N. M. Ukkali	Asst. Professor	M Tech.	Machine Design	LMISTE	--	06	9620152199
21	Prof. M. R. Inagalagi	Asst. Professor	M Tech.	Thermal Power Engg	LMISTE	--	05	9743868503
22	Prof. Jagadeesh A.	Asst. Professor	M Tech.	Thermal Power Engg	LMISTE	--	06	9902847774
23	Prof. R. V. Nyamagoud	Asst. Professor	M Tech.	Thermal Power Engg	LMISTE	--	05	9964822494
24	Prof. B. M. Dodamani	Asst. Professor	M Tech.	Energy System Engg	LMISTE	02	05	9535447575

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

Date	Events
10-02-2020	Commencement of IV/VI/VIII Semester Classes
10-02-2020 to 20-02-2020	II Semester Induction Program
15-02-2020	Annual Sports Meet
29-02-2020	Techno-Vision 2020
14-03-2020	EDP Activities
21-03-2020 to 24-03-2020	First CIE of II/IV/VI/VIII Semester
28-03-2020	Feedback-1, Submission of Feedback-1 report to office
28-03-2020	HSIT SAMBHRAMA-2020
11-04-2020	Technical Activities under Professional Bodies
18-04-2020	HSIT Quest - 2020
27-04-2020 to 29-04-2020	Second CIE of II/IV/VI/VIII Sem.
30-04-2020	Feedback-2, Submission of Feedback-2 report to office
26-05-2020 to 28-05-2020	Third CIE of II/IV/VI/VIII Sem.
29-05-2020	Project Exhibition of VIII Semester
29-05-2020 & 30-05-2020	Lab Internal Assessment of II/IV/VI Semester
03-06-2020 to 11-06-2020	SEE of VIII Semester (Theory)
01-06-2020	Last Working Day of IV/VI/VIII Semester
03-06-2020 to 13-06-2020	Practical Exams of II/IV/VI Semester
15-06-2020 to 20-06-2020	Project Viva-Voce of VIII Semester
15-06-2020 to 20-07-2020	SEE of II/IV/VI Semester (Theory)

February-2020

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

21- Maha Shivaratri , 22- Mahadasoha

March-2020

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

25- Chandramana Ugadi

April-2020

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		

06- Mahaveer Jayanti, 10- Good Friday,
14- Dr. B. R. Ambedkar Jayanti

May-2020

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

01- Labours Day, 25- Qutub-E-Ramazan

June -2020

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				

4th International Conference 2020- 2nd week of July, Graduation Day 2020- 3rd week of July

Dr. Shilpa Shirgur
IQAC Co-ordinator

Dr. S. C. Navale
Principal
Hirasugar Institute of Technology
NIDASOSHI 591 236

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, Programmes Accredited by NBA: CSE, ECE, EEE & ME.

MED
Calendar of Events
2019-20 (Even)
Rev: 00

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

Date	Events
27-01-2020 to 14-02-2020	Training Programme on CATIA and GD&T
10-02-2020	Commencement of IV/VI/VIII Semester Classes
28-02-2020	Industrial Visit for 8th Semester
29-02-2020	Books Awarding to Bright Students
07-03-2020	Industrial Visit for 6th Semester
13-03-2020	Technical Talk by Industrialist
23-03-2020 to 24-03-2020	First CIE of II/IV/VI/VIII Semester
03-04-2020	Technical Talk by Academician
27-04-2020 to 29-04-2020	Second CIE of II/IV/VI/VIII Sem.
08-05-2020	Hobby Project Competition
26-05-2020 to 28-05-2020	Third CIE of II/IV/VI/VIII Sem.
29-05-2020	Project Exhibition of VIII Semester
29-05-2020 & 30-05-2020	Lab Internal Assessment of II/IV/VI Semester
03-06-2020 to 11-06-2020	SEE of VIII Semester (Theory)
01-06-2020	Last Working Day of IV/VI/VIII Semester
03-06-2020 to 13-06-2020	Practical Exams of II/IV/VI Semester
15-06-2020 to 20-06-2020	Project Viva-Voce of VIII Semester
15-06-2020 to 20-07-2020	SEE of II/IV/VI Semester (Theory)

February-2020

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

21- Maha Shivaratri , 22- Mahadasoha

March-2020

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

25- Chandraman Ugadi

April-2020

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		

6- Mahaveer Jayanti, 10- Good Friday, 14- Dr. B.R. Ambedkar Jayanti

May-2020

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						

01- Labours Day, 25- Qutub-E-Ramazan

June -2020

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				

Prof. A.M. Shivashimpi
AIMSS Co-ordinator

Dr. B.M. Kulkarni
HOD

Mechanical Engg.
HIT, Nidasoshi

Scheme of Teaching and Examination

4rd Semester "A" division

IV SEMESTER

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					
BSC	18MAT41	Mathematics	Mathematics	2	2	--	03	40	60	100	3
PCC	18ME42	Applied Thermodynamics		3	2	--	03	40	60	100	4
PCC	18ME43	Fluid Mechanics		3	0	--	03	40	60	100	3
PCC	18ME44	Kinematics of Machines		3	0	--	03	40	60	100	3
PCC	18ME45A	Metal cutting and forming		3	0	--	03	40	60	100	3
	18ME45B	Metal Casting and Welding									
PCC	18ME46A or	Computer Aided Machine Drawing/		1	4						
	18ME46B	Mechanical Measurements and Metrology		3	0	--	03	40	60	100	3
PCC	18MEL47A /	Material Testing lab									
	18MEL47B	Mechanical Measurements and Metrology lab		--	2	2	03	40	60	100	2
PCC	18MEL48A	Workshop and Machine Shop Practice (Consists of Fitting, and Machining)		--	2	2	03	40	60	100	2
	18MEL48B	Foundry, Forging and Welding lab									
	OR										
	18CPH49	Constitution of India, Professional Ethics and Cyber Law		1	--	--	03	40	60		

VTU Scheme

IV SEMESTER

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					
BSC	18MAT41	Mathematics	Mathematics	2	2	--	03	40	60	100	3
PCC	18ME42	Applied Thermodynamics		3	2	--	03	40	60	100	4
PCC	18ME43	Fluid Mechanics		3	0	--	03	40	60	100	3
PCC	18ME44	Kinematics of Machines		3	0	--	03	40	60	100	3
PCC	18ME45A	Metal cutting and forming		3	0	--	03	40	60	100	3
	18ME45B	Metal Casting and Welding									
PCC	18ME46A or	Computer Aided Machine Drawing/		1	4						
	18ME46B	Mechanical Measurements and Metrology		3	0	--	03	40	60	100	3
PCC	18MEL47A or	Material Testing lab									
	18MEL47B	Mechanical Measurements and Metrology lab		--	2	2	03	40	60	100	2
PCC	18MEL48A	Workshop and Machine Shop Practice (Consists of Fitting, and Machining)		--	2	2	03	40	60	100	2
	18MEL48B	Foundry, Forging and Welding lab									
HSMC	18KVK49/49	Vyavaharika Kannada (Kannada for communication)/	HSMC	--	2	--	--	100	--	100	1
	18KAK49/49	Aadalitha Kannada (Kannada for Administration)									
	OR										
	18CPH49	Constitution of India, Professional Ethics and Cyber Law		1	--	--	03	40	60		
				Examination is by objective type questions							
			TOTAL	17	10	04	24	420	480	900	24
				OR	OR		OR	OR	OR		
				19	14		27	360	540		

Course	COMPLEX ANALYSIS, PROBABILITY AND STATISTICAL METHODS		
Course Code	18MAT41	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: Prof. S. A. Patil/Prof. S. S. Thabaj	**Designation:** Asst. Professor	**Experience:** 10/09
No. of times course taught: 01	**Specialization:** Mathematics	

1.0 Prerequisite Subjects:

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

2.0 Course Objectives

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

3.0 Course Outcomes

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

	Course Outcome	POs
CO1	Use the concepts of analytic function and complex potentials to solve the problems arising in Electromagnetic field theory.	1,2,3,12
CO2	Utilize conformal transformation and complex integral arising in aerofoil theory, fluid flow Visualization and image processing.	1,2,3,12
CO3	Apply discrete and continuous probability distributions in analyzing the probability models arising in engineering field.	1,2,3,12
CO4	Make use of the correlation and regression analysis to fit a suitable mathematical model for the Statistical data.	1,2,3,12
CO5	Construct joint probability distributions and demonstrate the validity of testing the hypothesis.	1,2,3,12
	Total Hours of instruction	**50**

4.0 Course Content

MODULE-I

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

Construction of analytic functions: Milne-Thomson method-Problems. **(10 Hours)**

MODULE-II

Conformal transformations: Introduction Discussion of transformations $w = z^2, w = e^z, w = z + \frac{1}{z}$ ($z \neq 0$).Bilinear transformations- Problems.

Complex integration: Line integral of a complex function-Cauchy's theorem and Cauchy's integral formula and Problems. **(10 Hours)**

MODULE-III

Probability Distributions: Review of basic probability theory. Random variables (discrete and continuous), Probability mass/density functions. Binomial, Poisson, exponential and normal distributions- problems (No derivation for mean and standard deviation)-Illustrative examples. **(10 Hours)**

MODULE-IV

Statistical Methods: Correlation and regression-Karl Pearson's coefficient of correlation and rank correlation -problems. Regression analysis- lines of regression –problems.

Curve Fitting: Curve fitting by the method of least squares- fitting the curves of the form-.

$y = ax + b, y = ax^b$ *and* $y = ax^2 + bx + c$ **(10 Hours)**

MODULE-V

Joint probability distribution: Joint Probability distribution for two discrete random variables, expectation and covariance.

Sampling Theory: Introduction to sampling distributions, standard error, Type-I and Type-II errors. Test of Hypothesis for means, student's t-distribution, Chi-square distribution as a test of goodness of fit. **(10Hours)**

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	Calculus of complex functions is 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	Probability Distributions used to design and Analysis of algorithm, interpreting data, Machine learning and artificial intelligence
03	Sampling Theory are used in design engineering, Sensors, image scanning, electricity generation & Quality of the products

7.0 Gap Analysis and Mitigation

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

8.0 Books Used and Recommended to Students

Text Books

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

Reference Books

1. N.P.Bali and Manish Goyal: A Text Book of Engineering Mathematics, Laxmi Publishers, 2014.
2. B.V.Ramana: "Higher Engineering Mathematics" Tata McGraw-Hill, 2006.
3. C. Ray Wylie,Louis C.Barrett: Advanced Engineering ,Mathematics, McGraw-Hill ,6th Edition 1995
4. S.S.Sastry: Introductory Methods of Numerical Analysis, Prentice Hall of India 4th Edition 2010
5. Chandrika Prasad and Reena Garg : Advanced Engineering ,Mathematics, Khanna Publishing, 2018
6. H. K. Dass and Er. RajnishVerma: "Higher Engineerig Mathematics", S. Chand publishing, 1st edition, 2011.

Additional Study material & e-Books

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

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

Website and Internet Contents References

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

10.0 Magazines/Journals Used and Recommended to Students

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

11.0 Examination Note

Internal Assessment: 40 Marks

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

Scheme of Evaluation for Internal Assessment (30 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.

1. The question paper will have **ten** full questions carrying equal marks.
2. Each full question consisting of **20** marks.
3. There will be **two** full questions (with a **maximum** of **four** sub questions) from each module.
4. Each full question will have sub question covering all the topics under a module.
5. 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	Review of a function of a complex variable, limits, continuity, differentiability	20
	2	Analytic functions-Cauchy-Riemann equation in Cartesian form	
	3	Problems	
	4	Cauchy-Riemann equation in Polar form	
	5	Problems	
	6	construction of analytic functions	
	7	Properties of Cauchy-Riemann equation	
	8	Problems	
	9	Milne-Thomson method	
	10	Problems	
MODULE 2	11	Conformal Transformations and discussion of transformations of $w = z^2$, $w = e^z$	20
	12	Discussion of Transformations: $w = z + (1/z)$.	
	13	Bilinear transformations	
	14	Problems	
	15	Complex line integrals-Cauchy's theorem	
	16	Cauchy's integral formula	
	17	Problems	
	18	Residue, poles	
	19	Cauchy's Residue theorem	
	20	Problems	
MODULE 3	21	Random variables (discrete and continuous)	20
	22	Probability mass/density functions	
	23	Binomial distribution.	
	24	Problems	
	25	Poisson distribution.	
	26	Problems	
	27	Exponential distribution.	
	28	Problems.	
	29	Normal distributions.	
	30	Problems.	
MODULE 4	31	Statistical Methods: Review of measures of central tendency and dispersion	20
	32	Correlation-Karl Pearson's coefficient of correlation	
	33	Problems	
	34	Regression analysis- lines of regression (without proof) –problems	
	35	Curve fitting by the method of least squares, of the form, form $y = ax+b$,	
	36	Problems.	
	37	Curve fitting by the method of least squares: $y = a+bx+cx^2$	
	38	Problems.	
	39	Curve fitting by the method of least squares $y = ae^{bx}$	
	40	Problems	

MODULE-3: Probability Distributions

1. Find the mean & variance of Binomial distribution.
2. The marks of 1000 students in an examination follows in a normal distribution with mean 70 & SD 5. Find the number of students whose marks will be i) less than 65 , ii) more than 75 & iii) between 65 & 75.
3. The probability mass function of a variate X is

$X = x_i$	-2	-1	0	1	2	3
p(x)	0.1	K	0.2	2k	0.3	k

4. Find i) The value of K, ii) $p(x \leq 0)$, iii) $p(x > 1)$ iv) $p(-2 < x \leq 1)$
5. If 10% of the rivets produced by a machine are defective, find the probability that, out of 12 rivets chosen at random.
6. S.T mean & standard deviation of exponential distribution are equal.
7. In a test of 2000 electric bulbs, it was found that the life of a bulb is a normal variable with average life of 2040 hours & standard deviation of 60 hours. Estimate the number of bulbs to burn for i) More than 2150 hours , ii) less than 1950 hours , Given that $p[0 \leq z \leq 1.83] = 0.4664$ & $p[0 \leq z \leq 1.33] = 0.4082$.
8. 2% of the fusion manufactured by a firm are found to be defective .Find the probability that a box containing 200 fuses contains i) no defective fuse , ii) 3 or more defective fuses.
9. In length of a telephone conversation is an exponential vitiate with mean 3 minutes. Find the probability that call i) ends in less than 3 minutes , ii) takes between 3 to 5 minutes.
10. Suppose that the student IQ scores form a normal distribution with average 100 & standard deviation 20. Find the percentage of students whose (i) score less than 80 (ii) score more than 120 (iii) score falls between 80 & 120 (G T P(1)=0.3413)
11. In a certain town the duration of a shower is exponentially distributed with mean 5 minutes what is

    the probability that a shower will least for i) 10 minutes or more, ii) less than 10 minutes, iii) betn 10 min & 12 min

12. The probability that a person aged 60 years will live upto 70 is 0.65. what is the probability that out of 10 persons aged 60 atleast 7 of them will live upto 70.

MODULE-4: Statistical Methods

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

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

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

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

3) Compute the rank correlation coefficient for the following data

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

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

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

Curve Fitting and Optimization:

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

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

MODULE 5	41	Joint Probability distribution for two discrete random variables	20
	42	Expectation, covariance.	
	43	Sampling & Sampling distributions	
	44	standard error, test of hypothesis for means and proportions	
	45	confidence limits for means	
	46	Problems.	
	47	student's t-distribution	
	48	Problems.	
	49	Chi-square distribution as a test of goodness of fit.	
	50	Problems	

14.0 QUESTION BANK

MODULE-1: Calculus of complex functions

1. Derive Cauchy-Riemann equations in the Cartesian form.
2. Derive Cauchy-Riemann equations in the Polar form.
3. P.T if f(z)= u+iv is an analytic then the family of curves u(x,y)=C1 , v(x,y)= C2, C1 & C2 being Constants, intersect each other orthogonally
4. S.T w = log z, $z \neq 0$ is analytic & find $\frac{dw}{dz}$.
5. Find the analytic function f(z) as a function of z given that the sum of its real & imaginary parts is
6. $x^3 + y^3 + 3xy(x - y)$
7. Determine the analytic function Whose imaginary part is $r^2\cos 2\theta$
8. Determine the analytic function Whose real part is $\frac{2\cos x\cosh y}{\cos 2x+\cosh 2y}$
9. Find the analytic function f(z)= u+iv given u-v= e^x(cosy-siny)
10. If $f(z)$ analytic show that $\left[\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right]|f(z)|^2 = 4|f'(z)|^2$

MODULE-2: Conformal transformations

1. Discuss the conformal transformation of $w = z^2$
2. Discuss the conformal transformation of $w = e^z$
3. Find the bilinear transformation which map the points z= 1, i, -i under this transformation find the image of |z| <1.
4. Find the bilinear transformation which maps z = ∞,i,0 into w=-1,-i,1. Also find the pts of transformation
5. State & prove Cauchy integral Theorem.
6. Verify Cauchy's theorem for the function f(z)= z^2 where c is the square having vertices
7. (0,0) ,(1,0),(1,1) & (0,1)
8. Evaluate $\int \frac{e^z}{z+i\pi}\,dz$ over each of the following contours C, a) |z| =2π , b) |z| =π/2 , c) |z-1|=1
9. State & prove Cauchy integral Theorem.

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

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

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

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

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

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

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

5) Fit a least square geometric curve $y = ax^b$ from the following data

x	1	2	3	4	5
y	0.5	2.0	4.5	8.0	12.5

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

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

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

MODULE-5: Joint probability distribution:

1. Explain the following terms i) Null hypothesis , ii) Level of significance , iii) Type I & II errors ,
   iv) Confidence limits.
2. A sample of 100 days is taken from meteorological records of certain districts & 10 of them are found to be fussy. Find the 99.73 % confidence interval of the % of fussy days in the distinct.
3. A certain stimulus administered to each of the 12 patients resulted in the following blood pressure 5,2,8,-1,3,0,6,-2,1,5,0,4, can it be calculated that stimulus will increase the blood pressure ?
   [$t_{0.05}$ for 11d.f= 2.201]
4. A die was thrown 9000 times & a throw of 5 or 6 was obtained 3240 times. On the assumption of random throwing, do the data abdicate that the die is biased?
5. A random sample of 100 records deaths in past year showed an average life span of 71.8 years. Assuming a population standard deviation of 8.9 years, does the data indicated that average life span today is greater than 70 years? Use a 0.05 level of significance.
6. In 324 throws of a six faced die, an odd number turned up 181 times. Is it reasonable to think that the die is an unbiased one?
7. Four coins are tossed 100 times & the following results were obtained

No. of Heads	0	1	2	3	4
Frequencies	5	29	36	25	5

   Fit a Binomial distribution for the data & test the goodness of fit given $\chi^2_{0.05} = 9.49$ for 4 d. f
8. Find the student's 't' for the following variable values in a sample of eight -4,-2,-2,0,2,2,3,3 taking the mean of the universe to be zero.
9. A coin was tossed 400 times & the head turned up 216 times. Test the hypotheses that the coin is in biased at 5% level significance.
10. A die was thrown 1200 times & the number 6 was obtained 236 times. Can the die be considered fair at level of significance?

11. The joint probability distribution for two random variables X and Y is as given below.

X \ Y	-2	-1	4	5
1	0.1	0.2	0	0.3
2	0.2	0.1	0.1	0

Find the marginal distributions of X, Y. Also find the covariance of X and Y.

12.The Joint probability distribution of two random variables X and Y is as follows

X \ Y	-4	2	7
1	1/8	1/4	1/8
5	1/4	1/8	1/8

13.Determine (i) Marginal distribution of X & Y (ii) E(X) , E(Y) and E(XY) (iii) Cov (XY) (iv) $\rho(XY)$.

14. A fair coin is tossed 4 times. Let X denotes the number of heads occurring and let Y denotes the longest string of heads occurring. Find the joint distribution function of X and Y.

16.0 University Result

Examination	S+	S	A	B	C	D	E	% Passing
July 2019	0	8	10	6	9	12	5	93.33

Prepared by	Checked by		
Prof. S. S. Thabaj/ Prof. S. A. Patil	Prof. S. L. Patil	HOD	Principal

Subject Title	**APPLIED THERMODYNAMICS**		
Subject Code	18ME42	**IA Marks**	40
No of Lecture Hrs + Tutorials Hrs / Week	03 L+ 02 T	**Exam Marks**	60
Total No of Lecture + Tutorial Hrs	50	**Exam Hours**	03
		CREDITS – 04	

FACULTY DETAILS:		
Name : Dr. B.M. Shrigiri	**Designation :** Professor/ HOD	**Experience :** 21 Years
No. of times course taught: 05	**Specialization:** Thermal Power Engineering	
Name: Prof. M. M. Shivashimpi	**Designation:** Assistant Professor	**Experience:** 12 Years
No. of times course taught: 10	**Specialization:** Thermal Power Engineering	

1.0 Prerequisite Subjects

Sl. No	Branch	Semester	Subject
01	Mechanical Engineering	I, II & III	Engineering Mathematics Elements of Mechanical Engg.
02	Mechanical Engineering	III	Basic Thermodynamics

2.0 Course Objectives

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

3.0 Course Outcomes

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

CO	Course Outcome	Cognitive Level	POs
C217.1	Apply thermodynamic concepts to analyze the performance of gas power cycles and Understand combustion of fuels and performance of I C engines.	L2,L3	PO1,P02,P04, PO6.PO7,PO12
C217.2	Apply thermodynamic concepts to analyze the performance of gas power cycles including propulsion systems.	L3	PO1,P02,P04, PO7,PO12
C217.3	Apply thermodynamic concepts to analyze the performance of vapor power cycles.	L3	PO1,P02,P04, PO7,PO12
C217.4	Understand the principles and applications of refrigeration systems. Apply Thermodynamic concepts to determine performance parameters of refrigeration and air-conditioning systems.	L2,L3	PO1,P02,P04, PO6.PO7,PO12
C217.5	Understand the working principle of Air compressors and Steam nozzles, applications, relevance of air and identify methods for performance improvement.	L2,L3	PO1,P02,PO3, PO6,PO12
Total Hours of instruction		**50 Hours**	

4.0 Course Content

Module - I

Air standard cycles: Carnot, Otto, Diesel, Dual and Stirling cycles, p-v and T -s diagrams, description, efficiencies and mean effective pressures. Comparison of Otto and Diesel cycles.

I.C.Engines: Classification of IC engines, Combustion of SI engine and CI engine, Detonation and factors affecting detonation, Performance analysis of I.C Engines, Heat balance, Morse test, IC Engine fuels, Ratings and Alternate Fuels.**10 Hours**

Module –II

Gas power Cycles: Gas turbine (Brayton) cycle; description and analysis. Regenerative gas turbine cycle. Intercooling and reheating in gas turbine cycles. Introduction to Jet Propulsion cycles.**10 Hours**

Module –III

Vapour Power Cycles: Carnot vapour power cycle, drawbacks as a reference cycle. Simple Rankine cycle; description, T-S diagram, analysis for performance. Comparison of Carnot and Rankine cycles. Effects of pressure and temperature on Rankine cycle performance.

Actual vapour power cycles. Ideal and practical regenerative Rankine cycles, open and closed feed water heaters. Reheat Rankine cycle. Characteristics of an Ideal working fluid in vapour power cycles.**10 Hours**

Module –IV

Refrigeration Cycles: Vapour compression refrigeration system; description, analysis, refrigerating effect. Capacity, power required units of refrigeration, COP, Refrigerants and their desirable properties, alternate Refrigerants. Air cycle refrigeration; reversed Carnot cycle, reversed Brayton cycle, vapour absorption refrigeration system.

Pscychrometrics and Air-conditioning Systems: Psychometric properties of Air, Psychometric Chart, Analyzing Air-conditioning Processes; Heating, Cooling, Dehumidification and Humidification, Evaporative Cooling. Adiabatic mixing of two moist air streams. Cooling towers.**10 Hours**

Module –V

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

Steam nozzles: Flow of steam through nozzles, Shape of nozzles, effect of friction, Critical pressure ratio, Supersaturated flow.**10 Hours**

5.0 Relevance to future subjects

Sl. No	Semester	Subject	Topics / Relevance
01	VIII	Project work	Application of IC engine, turbine, Compressor, Refrigeration and air-conditioning
02	V	Turbo machines	Euler's turbine equation, Steam turbine, compressor, pump and hydraulic turbine
03	VI	Heat and Mass Transfer	Boiling and condensation, Heat Exchanger

6.0 Relevance to Real World

SL. No	Real World Mapping
01	Application of IC Engine, Power generation from Gas turbine and steam turbine.
02	Analysis of actual cycle with reference of ideal cycles.
03	Design of air conditioners, compressor.
04	Actual analysis of combustion process in the IC engine, steam turbines, Gas turbines.
05	To control the environmental pollution.

7.0 Gap Analysis and Mitigation

Sl. No	Delivery Type	Details
01	Tutorial	Solving the unsolved problems from the reference and text books and demonstration in laboratory
02	Nptel.ac.in	E- Learning
03	VTU, E- learning	E- Learning
04	MOOCS	E- Learning
05	Open courseware	E- Learning

8.0 Books Used and Recommended to Students

Text Books
1. Engineering Thermodynamics, P.K. Nag, Tata McGraw Hill, 6th Edition 2018. 2.Applications of Thermodynamics, V.Kadambi, T. R.Seetharam, K. B. Subramanya Kumar, Wiley Indian Private Ltd, 1st Edition 2019. 3.Thermodynamics, Yunus A, Cengel,Michael A Boles, Tata McGraw Hill, 7th Edition
Reference Books
1. Thermodynamics for engineers,Kenneth A. Kroosand Merle C. Potter, Cengage Learning, 2016. 2. Principles of Engineering Thermodynamics, Michael J, Moran, Howard N. Shapiro, Wiley, 8th Edition. 3. An Introduction to ThermoDynamics, Y.V.C.Rao, Wiley Eastern Ltd, 2003. 4. Thermodynamics, Radhakrishnan, PHI, 2nd revised edition. 5. I.C Engines, Ganeshan.V, Tata McGraw Hill, 4th Edi. 2012. 6. I.C.Engines, M.L.Mathur& Sharma, Dhanpat Rai& sons- India.
Additional Study material & e-Books
1. Applied Thermodynamics by R.K Hedge and Niranjan Murthy
2. Thermal Engineering by R K. Rajput
3. Applied Thermodynamics by Kestur and Pravin

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

Website and Internet Contents References
1. https://www.youtube.com/watch?v=G02aeguJBwc
2. https://www.youtube.com/watch?v=CU28a-5Ker8
3. https://www.youtube.com/watch?v=vu9aNXlhbEI
4. https://www.youtube.com/watch?v=ub86Dhg67tM
5. https://www.youtube.com/watch?v=e2IryaMQQ6A
6. VTU, E- learning
7. http://auto.howstuffworks.com

10.0 Magazines/Journals Used and Recommended to Students

Sl. No	Magazines/Journals	website
1	Applied Thermal Engineering	http://www.sciencedirect.com/science/journal/13594311
2	Case Studies in Thermal Engineering	http://www.sciencedirect.com/science/journal/2214157X
3	Auto car India Magazine	http://www.autocarindia.com/Magazine/
4	Low-Tech magazines	http://www.lowtechmagazine.com/
5	Thermal News	http://www.thermalnews.com/main/

11.0 Examination Note

Internal Assessment: (30 marks for I.A. + 10 marks for assignment) = 40 Marks

SCHEME OF EXAMINATION:

- 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
I		**Air standard cycles and I.C. Engines**	20
	1	Carnot and Otto cycles, p-v and T -s diagrams, description, efficiencies and mean effective pressures.	
	2	Diesel and Dual cycles, p-v and T -s diagrams, description, efficiencies and mean effective pressures.	
	3	Stirling cycle, p-v and T -s diagrams, description, efficiency and mean effective pressure, Comparison of Otto and Diesel cycles.	
	4	Solving related numericals.	
	5	Solving related numericals.	
	6	Classification of IC engines, Combustion of SI engine and CI engine.	
	7	Detonation and factors affecting detonation, Performance analysis of I.C Engines.	
	8	Heat balance, Morse test, IC Engine fuels, Ratings and Alternate Fuels.	
	9	Solving related numericals.	
	10	Solving related numericals.	
II		**Gas power Cycles**	40
	11	Gas turbine (Brayton) cycle.	
	12	Description and analysis of Regenerative gas turbine cycle.	
	13	Description and analysis of inter cooling in gas turbine cycle.	
	14	Description and analysis of reheating in gas turbine cycle.	
	15	Introduction to Jet Propulsion cycles.	
	16	Solving related numericals.	
	17	Solving related numericals.	
	18	Solving related numericals.	
	19	Solving related numericals.	
	20	Solving related numericals.	
III		**Vapour Power Cycles**	60
	21	Carnot vapour power cycle, drawbacks as a reference cycle. Simple Rankine cycle; description, T-s diagram, analysis for performance.	
	22	Comparison of Carnot and Rankine cycles. Effects of pressure and temperature on Rankine cycle performance.	
	23	Actual vapour power cycles. Ideal and practical regenerative Rankine cycles.	
	24	Open and closed feed water heaters. Reheat Rankine cycle.	
	25	Characteristics of an Ideal working fluid in Vapour power cycles.	
	26	Solving related numericals.	
	27	Solving related numericals.	
	28	Solving related numericals.	
	29	Solving related numericals.	
	30	Solving related numericals.	
IV		**Refrigeration Cycles and Pscychrometrics &Air-conditioning Systems**	80
	31	Vapour compression refrigeration system; description, analysis, refrigerating effect. Capacity, power required, units of refrigeration, COP.	
	32	Refrigerants and their desirable properties, alternate Refrigerants. Air cycle refrigeration.	
	33	Reversed Carnot cycle, reversed Brayton cycle, Vapour absorption refrigeration system.	
	34	Solving related numericals	
	35	Solving related numericals	

12

	36	Psychometric properties of Air, Psychometric Chart.	
	37	Analyzing Air-conditioning Processes; Heating, Cooling, Dehumidification and Humidification.	
	38	Evaporative Cooling. Adiabatic mixing of two moist air streams. Cooling towers.	
	39	Solving related numericals	
	40	Solving related numericals	
V		**Reciprocating Compressors and Steam nozzles**	100
	41	Operation of a single stage reciprocating compressors. Work input through p-v diagram and steady state steady flow analysis.	
	42	Effect of Clearance and Volumetric efficiency. Adiabatic, Isothermal and Mechanical efficiencies.	
	43	Multi-stage compressor, saving in work, Optimum intermediate pressure, Inter-cooling, Minimum work for compression.	
	44	Solving related numericals.	
	45	Solving related numericals.	
	46	Solving related numericals.	
	47	Flow of steam through nozzles.	
	48	Shape of nozzles, effect of friction.	
	49	Critical pressure ratio, Supersaturated flow.	
	50	Solving related numericals.	

13.0 Assignments, Pop Quiz, Mini Project, Seminars

ASSIGNMENT-1

1. Draw neat P-V and T-S diagram of air standard dual cycle and derive an expression for air standard efficiency in terms of compression ratio, explosion ratio and cut off ratio. Under what conditions the dual cycle becomes Otto and diesel cycles.
2. Show the compression ratio for maximum work should be per kg of air in an Otto cycle between upper and lower limits of absolute temperature T3 and T1 is given by r = $\left(\frac{T3}{T1}\right)^{\left(\frac{1}{2(\gamma-1)}\right)}$ and also show that T2 T4 = $(T1\,T3)^{1/2}$.
3. Explain the following i) Morse Test ii) Heat balance sheet.
4. An air standard diesel cycle has a compression ratio 16. The temperature before compression is 27°C and the temperature after explosion is 627°C. Compute: i) Cut off ratio ii) The net work output per unit mass of air iii) Thermal efficiency iv) Mean effective pressure in bar.
5. A gas engine working on constant volume cycle gave the following results during a one hour test run: Cylinder diameter: 24 cm, stroke: 48 cm, effective diameter of the brake drum: 1.25 m, net load on the brake: 1236 N, Average speed: 226.7 rpm, Average explosions per minute: 77, MEP: 7.5 bar, gas used: 13m^3 at 15° C and 771 mm of mercury pressure, calorific value of gas: 22000 kJ/m^3 at NTP. Cooling water used 625 kg, rise in temperature of cooling water 35° C. Determine , mechanical efficiency, brake thermal efficiency, , indicated thermal efficiency, also draw up a heat balance sheet for the engine on percentage basis. Take NTP conditions as 760 mm of mercury and 0° C.

ASSIGNMENT-2

1. Derive an expression for optimum pressure ratio for maximum specific work output for i) ideal gas turbine cycle ii) actual gas turbine.
2. Explain with schematic diagram and T-S diagram Brayton cycle with i) Regenerator ii) intercooler and write the equation for the thermal efficiency.
3. With neat sketch, explain the working of ramjet.
4. In an open cycle gas turbine plant, air enters the compressor at 1 bar and 27° C. The pressure after compression is 4 bar. The isentropic efficiencies of the turbine and compressor are 85 % and 80 % respectively. Air fuel ratio is 80:1; calorific value of the fuel used is 42,000 kJ/kg. Mass flow rate of air is 2.5 kg/sec. Determine the power output from the plant and the cycle efficiency. Assume the value of Cp = 1.005 kJ/kgK and $\gamma = 1.4$.
5. In a gas turbine plant working on Brayton cycle with a regenerator of 75 % effectiveness the air at the inlet to the compressor is at 0.1 MPa and 30° C, the pressure ratio is 6 and maximum cycle temperature is 900° C. If the turbine and compressor have each of an efficiency 80 %. Find the percentage of increase in the cycle efficiency due to regeneration.

ASSIGNMENT-3

1. With a neat schematic diagram, P-V and T-S diagrams, explain the working of Rankine cycle. Derive the thermal efficiency expression for the same.
2. Discuss the effect of i) Boiler pressure ii) Condenser pressure iii) Super heat on the performance of a Rankine cycle.
3. With help of schematic diagram, T-S diagram and h-S diagram, explain regenerative vapor power cycle with one open feed water heater and derive an expression for its thermal efficiency.
4. 40 MW steam power plant working on Rankine cycle operates between boiler pressure of 40 bar and condenser pressure of 0.1 bar . The steam leaves the boiler and enters the steam turbine at 400° C. The isentropic efficiency of steam turbine is 84 %. Determine) the cycle efficiency ii) the quality steam from the turbine iii) steam flow rate in kg/hr considering pump work.
5. A steam power plant operates on a theoretical reheat cycle. Steam at boiler at 150 bar, 550 °C expands through the high pressure turbine. It is reheated at a constant pressure of 40 bar to 550 °C and expands through the low pressure turbine to a condenser at 0.1 bar. Draw h-s diagram. Find i) Quality of steam at turbine exhaust ii) Cycle efficiency iii) Steam rate in kg/kw-hr.

ASSIGNMENT-4

1. Write a brief note on properties of refrigerants.
2. With help of schematic diagram and appropriate psychrometric diagram explain summer air conditioning system for hot and dry outdoor condition.
3. Define the following: i) Wet bulb temperature ii) Dew point temperature iii) Relative humidity iv) Specific humidity v) Degree of saturation.
4. A cold of storage is to be maintained at -5 °C while the surroundings are at 35 °C. The heat leakage from the surroundings in to the cold storage is estimated to be 29 kW. The actual COP of the refrigeration plant is one third that of an ideal plant working between the same temperatures. Find the power required to drive the plant.
5. It is required to design an air conditioning plant for a small office room for the following winter conditions: Outdoor conditions : 14 ° C DBT and 10 ° C WBT, Required conditions 20 ° C DBT and 60 % RH, amount of air circulation = 0.3 m^3 /min/person, seating capacity of office = 60. The required condition is achieved first by heating and then by adiabatic humidifying. Determine the following i) Heat capacity of coil in KW and surface temperature required if the by- pass factor of coil is 0.4 ii) The capacity of the humidifier using psychometric chart

ASSIGNMENT-5

1. Derive an expression for the volumetric efficiency of a reciprocating air compressor.
2. Explain the following types of flow in a nozzle i) Frictionless adiabatic flow ii) Frictional adiabatic flow iii) Super saturated flow.
3. What is critical pressure ratio? Derive an expression for pressure ratio which gives maximum discharge through the nozzle.
4. A single stage single acting air compressor has cylinder bore of 15 cm and piston stroke of 25 cm. The crank speed is 600 rpm. The air taken from the atmosphere is at 1 bar and 27° C and delivered at 11 bar. Assuming both expansion and compression processes are according to the law $PV^{1.25}$ = Constant and clearance is 5 %. Determine: i) Power required to drive the compressor, assuming mechanical efficiency as 80 %; ii) What will be the change in power required to drive the compressor if clearance is 10 % with other conditions remaining same.
5. The steam expands from 3 bar to 1 bar in nozzle. The initial velocity is 900 m/s and initial temperature is 150° C. Determine the exit velocity of steam: i) If expansion is isentropic in nozzle ii) the nozzle efficiency is 95 %..

14.0 QUESTION BANK

Module 1: Air standard cycles and I.C. Engines

1. Derive the expression for the air standard efficiency of Diesel cycle with usual notations. State the assumptions made and represent the process on P-V and T-S diagram.
2. Compare Otto cycle and Diesel cycles, on the basis of the same compression ratio and same maximum pressure.
3. Compare Otto cycle and Diesel cycles, with help of PV and TS diagrams, based on the following conditions. i) When max. Cycle pressure and temp. are same. ii) When the compression ratio and heat addition are same.
4. With help of p-v and T-S diagrams, derive the expression for air standard efficiency of a semi diesel cycle or limited pressure cycle or dual cycle in terms of C.R. Cut of ratio and expansion ratio.
5. Derive the expression for the air standard efficiency of Otto cycle with usual notations. State the assumptions made and represent the process on P-V and T-S diagram.
6. List the methods used for finding out indicated power of internal combustion engine. Explain the method applicable to multi cylinder engine.
7. Briefly classify the IC engines.
8. Explain the combustion phenomenon of SI engine and CI engine.

9. Define detonation. What are the factors affecting for detonation?
10. What do you understand by Air standard cycle?

Numericals:

1. A Carnot cycle using air as the working substance works between temperature limits of 900 K and 300 K. The pressure limits are 60 bars and 1 bar. Determine (i) pressure at salient points of the cycle, (ii) the heat supplied per unit mass of air, (iii) net work output per unit mass of air, (iv) mean effective pressure and (v) thermal efficiency of the cycle.
2. The following data refers to an ideal sterling cycle with ideal regenerator. Pressure, temperature and volume of the working medium at the beginning of the volume of the cycle are 1110 of the initial volume. The maximum temperature attained in the cycle is 700°C.Draw PV and T-S diagrams. Calculate. i. The net work. ii. Thermal efficiency with 100% regenerator efficiency. iii. Thermal efficiency without the regenerator.
3. An ideal Otto cycle has a compression ratio of 8. The conditions at the beginning of compression stroke are 100 kPa and 17° C. If the heat added during the cycle is 800 kJ/kg find (i) temperatures and pressures at salient points of the cycle, (ii) net work output per unit mass of air, (iii) thermal efficiency of the cycle, (iv) mean effective pressure, (v) compression ratio corresponding to maximum work output, (vi) maximum work output and (vii) thermal efficiency corresponding to maximum work output.
4. An air standard diesel cycle has a compression ratio of 14. The air-condition at the beginning of compression is 1 bar and 27° C. The maximum temperature in the cycle is 2500 ° C. Determine (i) temperature and pressure at salient points of the cycle (ii) net work output per unit mass of air,(iii) thermal efficiency (iv)specific air consumption in kg/kWh and (v) MEP.
5. The pressures on the compression curve of a diesel engine are at $1/8^{th}$ stroke 1.4 bar and at $7/8^{th}$ stroke 14 bar. Estimate the compression ratio. Calculate the air standard efficiency and mean effective pressure of the engine if the' cut-off occurs at $1/15^{th}$ of the stroke. Assume initially air is at 1 bar and 27°C.
6. A four stroke, four cylinder petrol engine of 250mm bore and 375mm stroke works on the Otto cycle. The clearance volume is $0.01052m^3$• The initial pressure and temperature are 1bar and 47°C. If the maximum pressure is limited to 25bar, find the following: i) Air standard efficiency ii) Mean effective pressure.
7. A six cylinder, gasoline engine operates on the four stroke cycle. The bore of each cylinder is 80 mm and the stroke is 100 mm. The clearance volume in each cylinder is 70 cc. At a speed of 4000 rpm and the fuel consumption is 20 kg/h. The torque developed is 150 N-m. Calculate (i) the brake power, (ii) the brake mean effective pressure, (iii) brake thermal efficiency if the calorific value of the fuel is 43000 kJ/kg and(iv) the relative efficiency if the ideal cycle for the engine is Otto cycle.
8. The following observations have been made from the test of a four cylinder, two stroke petrol engine. Diameter of the cylinder = 10 cm; stroke = 15 cm; speed = 1600 rpm; Area of indicator diagram = 5.5 cm^2; Length of the indicator diagram = 55 mm; spring constant = 3.5 bar/cm; Determine the indicated power of the engine.
9. An eight cylinder, four stroke engine of 9 cm bore, 8 cm stroke and with a compression ratio of 7 is tested at 4500 rpm on a dynamometer which has 54 cm arm. During a 10 minute test, the dynamometer scale beam reading was 42 kg and the engine consumed 4.4 kg of gasoline having a calorific value of 44,000 kJ/kg. Air at 27° C and 1bar was supplied to the carburetor at a rate of 6 kg/min. Find (i) the brake power, (ii) the brake mean effective pressure, (iii) the brake specific fuel consumption (iv) the brake specific air consumption (v) volumetric efficiency (vi) the brake thermal efficiency and(vii) the air fuel ratio.
10. During a trial of 60 minutes on a single, cylinder on engine having cylinder dia. 300 mm 5toke 450 mm and working on two stroke cycle, the following observation were made. Total fuel used = 9.6litres, Calorific value of fuel = 45000 kJ/kg, Total number of revolutions = 12624, Gross mean effective pressure = 7.24 bar, Pumping mean effective pressure = 0.34 bar, Net load on brake = 3150 Newton, Diameter of brake drum = 1.78 m, Diameter of rope = 40 mm, Cooling water circulated = 545 liters, Cooling water temperature rise = 25°C, Specific gravity of oil = 0.8, Heat carried away by the exhaust gases = 15% total heat supplied. Determine IP, BP and mechanical efficiency. Draw up the heat balance sheet on minute basis.
11. The following data were obtained from a Morse test on a 4-cylinder, 4-stroke cycle SI engine coupled to a hydraulic dynamometer, operating a constant speed of 1500rpm. Brake load with all four cylinders firing = 296 N Brake load with cylinder No.1 not firing = 201 N Brake load with cylinder No.2 not firing = 206 N Brake load with cylinder No.3 not firing = 192 N Brake load with cylinder No.4 not firing = 200 N The brake power in kW is calculated using the equation BP = WN/42300, where W is the brake load in Newton's and N is the speed of the engine in rpm. Calculate i) Brake power ii) Indicated power Hi) Friction power iv) Mechanical efficiency.
12. During a test on a single cylinder 4 stroke oil engine the following observations were made Bore = 30cm, stroke = 45cm, duration of trail = 1hr, total fuel consumption = 7.6kg calorific value of fuel = 45,000 kJ/kg, total revolutions made = 12000, mean effective pressure 6 bar, net brake load = 1.47 kN. Brake drum diameter 1.8m rope diameter 3cm. Mass of jacket cooling water circulated = 550kg water enters at 150°C water leaves at 600°C. Total air consumption 360kg room temperature 200°C, exhaust gas temperature = 300°C. Calculate: i) Indicated and brake power; ii) Indicated thermal efficiency; iii) Mechanical efficiency; iv) Draw the heat balance sheet on minute basis.

Module 2: Gas Power Cycles

1. Explain the with neat sketches of Turbojet, turboprop, Ramjet and turbofan engines.
2. With neat T-S diagram explain the following i) inter cooling ii) reheating ii) regeneration.
3. Differentiate between open and closed gas turbines.
4. Discuss the Jet propulsion and rocket propulsion.
5. Derive an expression for the optimum pressure ratio, for the maximum network output, in a Brayton cycle. What is the corresponding cycle efficiency?
6. What are the methods of improving the efficiency of Brayton cycle?

Numericals :

1. An air standard Bray ton cycle has air entering the compressor at 100kPa and 27 ° C. The pressure ratio is 10 and the maximum allowable temperature in the cycle is 1350 K. Determine (i) temperatures at salient points of the cycle, (ii) compressor and turbine work per unit mass of air, (iii) net work output and work ratio, (iv) thermal efficiency of the cycle, (v) specific air consumption in kg/kWh, and (vi) improvement in the thermal efficiency of the cycle if a regenerator with 100 % effectiveness is incorporated in the cycle.
2. Determine the net work output and thermal efficiency of an ideal gas turbine cycle having two stages of compression with inter cooling in between the stages and two stages of expansion with reheating in between the stages. The overall pressure ratio for the cycle is 4 and the maximum cycle temperature is 900° C Assume that the atmospheric temperature is 15° C and the cycle is designed for maximum work output. Draw the schematic and T-s diagrams for the cycle. What would be the improvement in the thermal efficiency if an ideal regenerator is incorporated in the cycle?
3. The pressure ratio of an open cycle gas turbine cycle is 6. The compressor inlet conditions are 1 bar and 15 ° C. The maximum temperature in the cycle is 800 °C. The isentropic efficiency of compressor is 85 % and that of the turbine is 90%. The combustion efficiency is 95 %. There is a pressure drop of 2 % of the inlet pressure in the combustion chamber. The calorific value of the fuel used is 42,000kJ/kg. Assuming that the values of Cp remain same throughout the cycle and equal to 1.4 and 1.005 kJ/(kg-K) respectively determine (i)net work output per unit mass of air,(ii) air-fuel ratio, (iii) thermal efficiency of the plant, (iv) specific fuel combustion in kg/kWh, and (v) power output from the plant for a mass flow rate of air of 1.0 kg/s.
4. In a reheat gas turbine cycle, comprising one compressor and two turbines, air is compressed from 1 bar, 27°C to 6 bar. The highest temperature in the cycle is 900°C. The expansion in the first stage turbine is such that the work from it just equals the work required by the compressor. Air is reheated between the two stages of expansion to 850°C. Assume that the isentropic efficiency of the compressor, the first stage and the second stage turbines are 85% each and that the working substance is air. Calculate the cycle efficiency,.
5. Air enters the compressor of an ideal air standard Brayton Cycle at 100 kPa, 300K with a volumetric flow rate of $6m^3/S$. The compressor pressure ratio is 10. The turbine inlet temperature is 1500K. Determine. i) The thermal efficiency. ii) Work ratio iii) Power developed.
6. In a gas turbine plant working on Brayton cycle with a regenerator of 75% effectiveness, the air at the inlet to the compressor is at 0.1 MPa, 30°C, the pressure ratio is 6 and the maximum cycle temperature is 900°C. If the turbine and compressor have each an efficiency of 80%, find the percentage increase in the cycle efficiency due to regeneration.
7. In an open cycle gas turbine plant air enters the compressor at 1 bar and 27°C. The pressure after compression is 4 bar. The isentropic efficiencies of the turbine and the compressor are 85% and 80% respectively. Air fuel ratio is 80: 1. Calorific value of the fuel used is 42000 KJ /kg. Mass flow rate of air is 2.5 kg/s. Determine the power output from the plant and the cycle efficiency. Assume that 'Cp' and γ to be same for both air and products of combustion. \
8. The air enters the compressor of an open cycle constant pressure gas turbine at a pressure of 1bar and temperature 20°C. The pressure of the air after compression is 4 bar. The isentropic efficiencies of compressor and turbine are 80% and 85% respectively. The air-fuel ratio used is 90: 1. The flow rate of air is 3 kg/s. C.V = 420000 kJ/kg is used Cp = 1.005 kJ/kg K, γ = 1.4 assume CP and r remains same for air and gases. Find i) Power developed ii) Thermal efficiency of the cycle.

Module 3: Vapour Power Cycles

1. Sketch the flow diagram and corresponding temperature – entropy of a reheat cycle and derive an expression for reheat cycle efficiency. What are the advantages gained by the steam between stages?
2. Draw the line diagram and T-S diagram for vapor power cycle practical regenerative Rankine cycle with closed feed water heaters.
3. Draw the line diagram and T-S diagram for vapor power cycle practical regenerative Rankine cycle with open feed water heaters.
4. Explain with T-S diagrams, limitations of Carnot cycle and how we can overcome the same in Rankine cycle.
5. Discuss the effect of i) Boiler pressure and ii) Condenser pressure, on the performance of a Rankine cycle

Numericals :

1. In a simple Rankine cycle, steam conditions at the boiler exit are 10 bar and 300° C. In the pipe line between the boiler exit and turbine inlet, there is an energy loss of 50 kJ/kg and a drop in pressure of 0.5 bars. The steam expands in the turbine to a pressure of 0.09 bars. The isentropic efficiency of the turbine is 0.86 and that of the pump is 0.70.

Determine (i) the condition of steam entering the turbine, (ii) actual pump work per unit mass of water, (iii) turbine work per unit mass of steam (iv) net work output and thermal efficiency of the cycle, and (v) quality of steam entering the condenser.

2. In a reheat steam cycle, the boiler exit conditions are 25 bar and 300 ° C. The exit pressure of steam at the end of first stage is 5 bar. The steam is then reheated to300 ° C before expanding in the second turbine to 0.05 bar. Assuming the high and low pressure turbines to have efficiencies of 87% and85 % respectively, find (i) the thermal energy input in the reheater, (ii) the cycle efficiency (iii) specific steam consumption and (iv) power output for a mass flow rate of 2 kg/s.
3. Compare the performance of an ideal reheat cycle with that of a simple Rankine cycle in terms of (i)net work output (ii) thermal efficiency (iii) steam rate and iv) quality of steam entering the condenser assuming the following data. Boiler exit conditions are 15 bars and 300 C. Condenser pressure is 0.1 bars. Reheating pressure is 4bar. The steam is reheated at constant pressure back to its original temperature in the reheater.
4. In -a reheat cycle, steam at 500°C expands in a HP turbine till it is saturated vapour. It is then reheated at constant pressure to 400°C and then expanded in a LP turbine to 40°C. H the maximum moisture content at the turbine exhaust is limited to 15% find, i) the reheat pressure ii) the pressure of steam at the inlet to the HP turbine iii) the net specific work output iv) the cycle efficiency v) the steam rate. Assume all the ideal processes.
5. Steam, from a-boiler enters a turbine at 25 bars and expands to condenser pressure of 0.2 bar. Determine the Rankine cycle efficiency neglecting pump work i) When steam is 80%dry at turbine inlet ii) When steam is saturated at turbine inlet iii) When steam is superheated at turbine inlet iv) Represent above 3 processes on same T-S diagram.

Module 4: Refrigeration Cycles and Pscychrometrics & Air-conditioning Systems

1. Draw neat P-V and T-S diagrams for reversed Brayton cycle and derive COP.
2. What is one ton of refrigeration?
3. Distinguish between refrigeration and refrigerator.
4. Write note on properties of refrigerants.
5. With a neat sketch, describe the clearly the working of a Bell – Coleman cycle.
6. Derive an expression for an Air refrigeration system.
7. Explain the effect of superheat and sub cooling on the vapour compression cycle with the help of T-S and p-h diagrams.
8. With a neat sketch, explain the working of vapour absorption refrigeration system.
9. With a schematic diagram, explain the summer air conditioning system for hot and wet weather
10. With a neat schematic diagram, explain the working of winter air conditioning system. Represent the processes on psychometric chart.
11. Define i) Specific humidity ii) degree of saturation iii) relative humidity.
12. With neat sketch describe the a summer air condition system
13. Represent the following processes on psychrometric chart i) Heating and humidifying ii) sensible heating iii) sensible cooling iv) cooling and dehumidifying.

Numericals :

1. A reversed Carnot cycle is used for heating and cooling. The work supplied is 10 kW. If the COP is 3.5 for cooling determine (i) the ratio of maximum temperature to minimum temperature in the cycle (ii) refrigeration effect in tons and (iii)COP if the cycle is used as a heat pump.
2. An ideal air refrigeration cycle has the following specifications: Pressure of air at compressor inlet = 101 kPa; Pressure of air at turbine inlet = 404 kPa; Temperature of air at compressor inlet = −6 ° C; Temperature of air at turbine inlet = 27 ° C; Determine (i) The COP of the cycle, (ii) Power required to produce 1 ton of refrigeration, and (iii) air circulation rate per ton of refrigeration.
3. In an air refrigerating machine, the compressor takes in air at 1 bar and10 ° C. After compression to 5.5 bar, the air is cooled to 30 ° C before expanding it back to 1bar. Assuming ideal conditions, determine (i) refrigeration effect per unit mass of air (ii) heat rejected by air per unit mass in the intercooler and (ii) COP of the cycle, In an actual plant using the above cycle, the air flow rate is 1700 kg / h and the relative COP of the actual plant is 0.65. Determine the power required for the actual plant for the same refrigerant.
4. In a saturated vapour compression refrigeration cycle operating between an evaporator temperature of -10°C and a condenser temperature of 40°C, the sub enthalpy of the refrigerant, Freon-12 at the end of compression is 220 kJ /kg. ease Show the cycle on T-S and p-h planes. Calculate i) COP ii) refrigerating capacity and compressor power assuming a refrigerating flow rate of 1 kg/min.
5. For a hall to be air-conditioned, the following conditions are given: Outdoor conditions: 40° DBT, 20°C WBT, required comfort condition 20°C WBT, 60% RH. Seating capacity of the hall is 1500, amount of outdoor air supplied = 0.3 m^3/min per person. If the required condition is achieved first by adiabatic humidification and then by cooling, estimate i) the capacity of the cooling coil in tones and ii) the capacity of the humidifier in kg/h.
6. Moist air at 35 ° C has dew point of 15 ° C. Calculate its relative humidity, specific humidity and enthalpy. Take Cp_v = 1.88 KJ /kg K. 7. 30 m^3 /min. of air at 15 ° C DBT and 13 ° C WBT is mixed 12 m^3 /min. of air at 25 ° C DBT and 18

17

° C WBT. Calculate DBT, specific humidity of mixture. Take atm. Pressure as 760 mm of Hg. Calculate by calculation method only.

7. A sling psychrometer reads 40°C D.B.T and 28°C W.B.T. calculate the following. i) Specific humidity ii) Relative humidity iii) Vapour density in air iv) Dew point temperature v) Enthalpy of mixture per kg of dry air.

Module 5: Reciprocating Compressors and Steam nozzles

1. Derive an expression for work done in a reciprocating air compressor i) without clearance ii) with clearance.
2. What is the purpose of multi staging in reciprocating compressor?
3. Derive an expression for work done for single stage, single acting reciprocating compressor with clearance volume
4. Derive an expression for the condition for the minimum work input, required for a two stage compressor, with perfect inter cooling.
5. What are the draw backs of a single stage compressor for producing high pressure? How are these overcome by multistage compression?
6. Show that for a multistage compressor $Z= (Px+1P1)^{1/x}$ where Z=stage pressure ratio, x = number of stages, $(Px+1/P1)$ overall pressure ratio.
7. Explain the following types of flow in a nozzle i) Frictionless adiabatic flow ii) Frictional adiabatic flow iii) Super saturated flow.
8. What is critical pressure ratio? Derive an expression for pressure ratio which gives maximum discharge through the nozzle.

Numericals:

1. A double acting compressor, with a piston displacement of 0.05 m^3 per stroke, operates at 500 rpm. The clearance is 5 percent and it receives air at 100 KPa and discharges at 600 KPa. The compression is polytrophic according to the law $PV^{1.35}$ =constant. Determine the power required to drive the compressor and the mass of air delivered in kg/s if the suction temperature is 27° C.
2. A single acting air compressor has a cylinder of bore 15 cm and the piston stroke is 25 cm. The crank speed is 600 rpm. Air is taken from atmosphere (1 bar and 27° C) and is delivered at 11 bars. Assuming polytrophic compression of the type $PV^{1.25}$ = C, find the power required to drive the compressor if its mechanical efficiency is 80%. The compressor has a clearance which is 1/20th of the stroke volume. How long will it take to deliver 1 m^3 of air at the compressor inlet conditions? Also find the volumetric efficiency of the compressor.
3. A reciprocating compressor has a 5 % clearance with a bore and stroke of 25 x 30 cm. The compressor operates at 500 rpm. Air enters the cylinder at 27 ° C and 95KPa and discharges at 2000 KPa. If the indices for both compression and expansion are equal to 1.3. Determine (i) volumetric efficiency (ii) the volume of air handled at inlet conditions in m^3/s (iii) the power required to drive the compressor if the mechanical efficiency is 90 % (iv) the mass of air delivered in kg/s, (v) the mass of air in the clearance space.
4. An air compressor takes air at 1 bar and 20° C and compresses the same according to the law $PV^{1.2}$ = C. It then delivered to a receiver at a constant pressure of 10 bar. Determine i) Temperature at the end of compression ii) Work done and Heat Transferred during compression, per kg of air. R = 0.287 KJ/kg K.
5. Two stage, single acting reciprocating air compressor, with complete intercooling atmospheric air at 1 bar and 15°C, compresses it polytropically (n = 1.3) to 30 bar. Both cylinders have the same stroke; calculate the diameter of the HP cylinder. The diameter of the LP cylinder is 300mm.
6. Air at standard atmospheric conditions is compressed and delivered to a receiver of 0.4 m diameter and 1 m long until a final pressure of 10 atm is reached. Assuming ideal conditions with no valve pressure drops, compute the power needed to drive the compressor for (i) isothermal compression, (il) polytropic compression with n = 1.32. Assume that the receiver temperature is maintained atmospheric throughout and filing takes place in 5 min. Atmospheric temperature is 25°C. Also calculate isothermal efficiency of the compressor.
7. The steam expands from 3 bar to 1 bar in nozzle. The initial velocity is 900 m/s and initial temperature is 150° C. Determine the exit velocity of steam: i) If expansion is isentropic in nozzle ii) the nozzle efficiency is 95 %.

15.0 University Result

Examination	S+	S	A	B	C	D	E	% Passing
June _July 2019	0	0	0	0	2	23	12	59.79
May _June 2018	0	0	2	3	7	15	33	54.2 %

Prepared by	Checked by		
Prof. M.M. Shivashimpi	Dr. B. M. Shrigiri	HOD	Principal

Subject Title	FLUID MECHANICS		
Subject Code	18ME43	IA Marks	40
No of Lecture Hrs + Tutorial Hrs / Week	03+02	Exam Marks	60
Total No of Lecture + Practical Hrs	50+0	Exam Hours	03
			CREDITS – 03

FACULTY DETAILS:		
Name: Dr. S.N.Topannavar	Designation: Assoc. Professor	Experience: 21 Years
No. of times course taught: 7 Times	Specialization: Thermal Power Engg.	
Name: Prof.R.V. Nyamagoud	Designation: Asst. Professor	Experience: 06Years
No. of times course taught: 3Times	Specialization: Thermal Power Engg.	

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
Mechanical Engineering	I/II/III/IV	Engg. Mathematics	Mechanical Engineering
Mechanical Engineering	III	Basic thermodynamics	Mechanical Engineering

2.0 Course Objectives

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

3.0 Course Outcomes

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

CO	Course Outcome	Cognitive Level	POs
CO1	Understand and Formulate the properties of fluids, static pressure on submerged body.	L3	PO1,PO2,PO6, PO9,PO12
CO2	Interpret and apply the principles of fluid buoyancy and kinematics	L3	PO1,PO2,PO4, PO9,PO12
CO3	Apply the knowledge of fluid dynamics while addressing problems of mechanical engineering and understand the laminar and turbulent flows to formulate the correlations for the different fluid flows and analysis of different losses during the flow.	L3	PO1,PO2,PO4, PO9,PO12

C04	Analyze the flow over bodies and dimensional analysis.	L4	PO1,PO2,PO3, PO6,PO12
C05	Understand the basic concepts of compressible flow and applications of CFD.	L2	PO1,PO2,PO6, PO7,PO12
	Total Hours of instruction	**50**	

4.0 Course Content

Module-1

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

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

Module-2

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

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

Module-3

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

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

Module-4

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

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

Module-5

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

Introduction to CFD: Necessity, limitations, philosophy behind CFD, applications.

5.0 Relevance to future subjects

SL. No	Semester	Subject	Topics / Relevance
1	V	Turbo machines	Analysis, Design and Development of fluid machines
2	VI	Heat and Mass Transfer	Convection heat transfer
3	VII	Hydraulics and pneumatics	Design and Development of hydraulic and pneumatic valves

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4	VIII	Power plant engineering	Fluid flow analysis in power plant equipments
5	V	Fluid Mechanics and Machinery Lab	Fluid properties and flow analysis

6.0 Relevance to Real World

SL. No	Real World Mapping
01	Design and Development of Fluid flow and heat transfer equipments in industries
02	Pipe net work design to distribute the fluid in industries, agriculture and society
03	Fluid flow analysis and system design for living organisms

7.0 Books Used and Recommended to Students

Text Books

1 A Text Book of Fluid Mechanis And Hydraulic Machines Dr R.K Bansal Laxmi Publishers
2 Fluid Mechanics F M White McGraw Hill Publications Eighth edition. 2016
3 Fluid Mechanics (SI Units) Yunus A. Cengel John M.Cimbala TataMcGraw Hill 3rd Ed.,2014.

Reference Books

1 Fluid Mechanics F M White McGraw Hill Publications Eighth edition. 2016
2 Fundamentals of Fluid Mechanics Munson, Young, Okiishi&Huebsch, John Wiley Publications 7th edition
3 Fluid Mechanics Pijush.K.Kundu, IRAM COCHEN ELSEVIER 3rd Ed. 2005
4 Fluid Mechanics John F.Douglas, Janul and M.Gasiosek and john A.Swaffield Pearson Education Asia 5th ed., 2006
5 Introduction to Fluid Mechanics Fox, McDonald John Wiley Publications 8th edition.

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. Fluid Mechanics related websites

9.0 Magazines/Journals Used and Recommended to Students

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

10.0 Examination Note

Internal Assessment: 30 Marks for IA Tests +10 Marks for Assignments
Theoretical aspects as well as relevant sketches should be drawn neatly for questions asked in Internal Assessments and assignments

Scheme of Evaluation for Internal Assessment

Internal Assessment test in the same pattern as that of the main examination (Average of 3 Tests):30marks.

SCHEME OF EXAMINATION:

- There are five modules two questions from each module
- Student has to answer any five question choosing at least one questions from each module.

Max. Marks: 60Marks

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

11.0 Course Delivery Plan

Module No.	Lecture No.	Content of Lecture	% of Portion
1		**Basics Properties of Fluids**	25
	1	Introduction, properties of fluids, viscosity	
	2	Thermodynamic properties, Surface tension and Capillarity	
	3	Vapour pressure and Cavitation.	
	4	Solving of related numericals.	
		Fluid Statics	
	5	Fluid pressure at a point, Pascal's law, pressure variation in a static fluid, Absolute, gauge, atmospheric and vacuum pressures	
	6	simple manometers, differential manometers	
	7	total pressure and center of pressure, vertical plane surface submerged in liquid,	
	8	horizontal plane surface submerged in liquid	
	9	Inclined plane surface submerged in liquid curved surface submerged in liquid	
	10	Solving of related numerical.	
2		**Buoyancy**	20
	1	Buoyancy, center of buoyancy,	
	2	meta-center and meta-centric height,	
	3	conditions of equilibrium of floating bodies	
	4	submerged bodies	
		Fluid Kinematics	
	5	Types of fluid flow,	
	6	continuity equation, continuity equation in 3 dimensions (Cartesian co-ordinate system only)	
	7	velocity and acceleration	
	8	velocity potential function and stream function	
	9	Solving of related numerical	
		Fluid Dynamics	
	1	Introduction, equations of motion, Euler's equation of motion	
	2	Bernoulli's equation from Euler's equation	
		Bernoulli's equation for real fluids	

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	3	Momentum equation, Impacts of jets- force on fixed and moving vanes, flat and curved	
	4	Introduction, venturimeter, orifice meter	
		Pitot tube, V-Notch and rectangular notches.	
	5	Solving of related numerical	
3		**Laminar and Turbulent flow**	15
	6	Reynolds Number, Entrance flow and Developed flow, Navier- Stokes Equation (no derivation)	
		Laminar flow between parallel plates, Poiseuille equation – velocity profile,	
		Couette flow, Fully developed laminar flow in circular pipes, Hagen - Poiseuille equation.	
	7	Solving the related problems	
	8	Frictional loss in pipe flow.	
		Darcy- Equation for loss of head due to friction in pipes	
		Commercial pipe, Colebrook equation	
	9	Moody equation/ diagram. Pipes in series	
		parallel, equivalent pipe	
	10	Related Numericals and simple pipe design problems.	
4		**Flow over bodies:**	25
	1	Development of boundary layer, Prandtl's boundary layer equations,.	
	2	Blasius solution, laminar layer over a flat plate,	
	3	boundary layer separation and its control. Basic concept of Lift and Drag,	
	4	Types of drag, Co-efficient of drag and lift, streamline body and bluff body,	
	5	flow around circular bodies and airfoils, Lift and drag on airfoil, Numericals.	
		Dimensional analysis:	
	6	Need for dimensional analysis,	
	7	Dimensions and units, Dimensional Homogeneity and dimensionless ratios,	
	8	methods of dimensional analysis, Rayleigh's method, Buckingham Pi theorem,	
	9	Similitude and Model studies. Numericals	
	10	Solving of related numericals.	
5		**Compressible Flows:**	15
	1	Introduction	
	2	thermodynamic relations of perfect gases	
	3	internal energy and enthalpy, speed of sound	
	4	pressure field due to a moving source	
	5	basic Equations for one- dimensional flow,	
	6	stagnation and sonic Properties,	
	7	normal and oblique shocks	
		Introduction to CFD:	
	8	Necessity, limitations,	
	9	philosophy behind CFD,	
	10	Applications of CFD	

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 Introductory concepts and definitions	Solve Numericals related to CO1	Module 1	3	Individual Activity.	Text Books
2	Assignment 2: Questions on	Derive expressions and Solve Numericals	Module 2	6	Individual Activity.	Text Books

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	Dynamics of flow	related to CO2				
3	Assignment 3: Questions on One-Darcy Weishach	Derive expressions and Solve Numericals related to CO3	Module 3	8	Individual Activity.	Text Books
4	Assignment 4: Questions on flow over bodies	Derive expressions and Solve Numericals related to CO4	Module 4	10	Individual Activity.	Text Books
5	Assignment 5: Compressible flow Introduction to CFD	Derive expressions and Solve Numericals related to CO5	Module 5	11	Individual Activity.	Reference book s

13.0 Assignment question bank

ASSIGNMENT: 1

Date: *27.2.18*

Module 1		
Q. No	**Description of Question**	**Marks**
1	Define fluid classify the same. Define (1) Fluid Mechanics, (2) Hydromechanics, (3) Fluid static, (4) Hydrostatic	5
2	Define Density, specific weight, sp.volume and sp. Gravity.	5
3	Explain capillarity and derive an expression for i) Capillary rise and ii) capillary fall depression.	5
4	State and prove Pascal's Law	5
5	Numericals: from F M White	5

ASSIGNMENT: 2

Date: *20.3.18*

Module 2		
Q. No	**Description of Question**	**Marks**
1	What are the Types of fluid flow and explain laminar and turbulent flow.	5
2	Derive an expression for continuity equation in 3 dimensions (Cartesian co-ordinate system only)	5
3	Derive an expression for Bernoulli's equation from Euler's equation	5
4	Derive an expression for venturimeter	5
5	Numerical related to Bernoulli's equation, velocity potential function and stream function and flow rate measuring devices.	5

ASSIGNMENT: 3

Date: *10.4.18*

Module 3		
Q. No	**Description of Question**	**Marks**
1	Derive an expression for Hagen - Poiseuille equation	5
2	Solving the related problems	5
3	Derive an expression for Darcy- Equation for loss of head due to friction in pipes	5
4	Solving the related problems	5
5	Derive an expression for Laminar flow between parallel plates.	5

ASSIGNMENT: 4

Date: *27.4.18*

Module 4		
Q. No	**Description of Question**	**Marks**
1	State Buckingham's π theorem. The tip deflection δ of a cantilever beam is a function of tip load W, beam length l, second moment of area I and Young's modulus E. Perform a dimensional analysis of this problem.	5
2	Explain the following i) Drag ii) Lift	5
3	Explain the following i) Momentum thickness ii) Mach number iii) Mach cone	5
4	A flat plate 1.8m x1.8 m moves at 36 krn/hr in stationary air of density 1.2 kg/m3. If the coefficient of drag and lift are 0.15 and 0.75 respectively. Determine: i) The lift force ii) The drag force iii) The resultant; force iv) Power required to keepthe plate in motion.	5
5	Distinguish between i) Streamline body and bluff body ii) Friction drag and pressure drag.	5

ASSIGNMENT: 5 Date: *15.5.18*

Module 5		
Q. No	**Description of Question**	**Marks**
1	Write a note on necessity of CFD.	5
2	Derive an expression for stagnation pressure	5
3	Derive an expression for stagnation density and temperature	5
4	Define stagnation density , temperature and pressure	5
5	Related numerical	5

14.0 QUESTION BANK

MODULE-1: Basics Properties of Fluids and Fluid Statics

1. Define fluid classify the same. Define (1) Fluid Mechanics, (2) Hydromechanics, (3) Fluid static, (4) Hydrostatic, (5) Fluid kinematics, (6) Hydro kinematics, (7) Fluid dynamics, (8) Hydrodynamics, (9) Hydraulics.
2. What do you mean by continuum concept of fluid?
3. Define Density, specific weight, sp.volume and sp. Gravity.
4. What is viscosity? Explain in brief. Derive an equation for absolute or dynamic viscosity and write its unit in S.I. Also define kinematics viscosity. Write its equation and S.I. Unit. Relate poise, centipoises, stoke, Centistokes with units of viscosities in S.I
5. Describe in brief thermodynamic properties of fluids.
6. Explain capillarity and derive an expression for i) Capillary rise and ii) capillary fall depression.
7. Numericals: from books
8. What is static fluid?
9. Define pressure. Derive an expression for pressure at a point below free surface of liquid. Also derive a general form of equation for pressure variation in a static fluid. Define pressure head
10. State and prove Pascal's Law.
11. Describe guagepr ; atmospheric pr, vacuum pr and absolute pr.
12. Describe mechanical guage. Sketch and explain Bourdon tube pressure guage.
13. Describe monometer. Classify it. Explain in brief (1) Piezometer, U-Tube manometer single column manometer, Differential manometer, inverted U-Tube manometer and derive their respective equations.
14. Numericals Ref FM – Pijush.K.Kundu
15. Define total or resultant pressure force and center of pressure. Derive an expression for total pressure force & position of C.P for the following conditions I) vertical plane surface submerged in liquid ii) Horizontal plane surface submerged in liquid iii) Inclined plane surface submerged in liquid.
16. Define the term buoyancy and center of buoyancy.
17. Explain the term metacentre and meta centric height.
18. Derive an analytical expression for the metacentric height of a floating body.
19. Describe in brief experimental method of determing metacentric height.
20. What are the conditions of equilibrium of a floating body and a submerged body

MODULE-2: Fluid Kinematics and Fluid Dynamics

1. Define kinematics of flow. What are the different methods of describing fluid motion.
2. Define the following types of line: i) Path line ii) stream line iii) Stream tube iv) Potential line, v) Streak or filament line.
3. Define the following types of fluid flow: 1) steady and unsteady flow 2) Uniform and non uniform flow 3) Laminar, transition and turbulent flow 4) Compressible and incompressible flow. 5) Rotational and irrigational Flow 6) One – Two and Three dimensional Flow.
4. Define continuity equation . Write its equation Derive the continuity equation for the three dimensional flow in Cartesian co-ordinates and modify it for two and one dimensional flow.
5. Describe velocity and Acceleration of fluid particles. Also explain local acceleration and concoctive acceleration.
6. Describe with sketches 4 important types of motion.
7. What do you mean by velocity potential function and stream function. Also write their proper ties.
8. Explain equipotential line and line of constant stream function. Also relate steam function and velocity potential Function.

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9. Numerical:
10. Name the different forces present in a Fluid flow. For the Euler's equation of motion, which forces are taken into consideration?
11. What is Euler's equation? How will you obtain Bernoulli's equation form it?
12. State Bernoulli's theorem for steady flow of an incompressible fluid. Derive an expression for Bernoulli's theorem from the first principle and state the assumptions made for such a derive. Also write it applications.
13. Numericals
14. What is venturimeter? Derive an expression for the discharge through a venturimeter.
15. What is orificemeter. Derive an expression for discharge through an orificemeter.
16. What is pitot – tube? How will you determine the velocity at any point with the help of pitot – tube?
17. What is the difference between pitot tube and pitot – static tube?
18. Numericals :
19. What is V-notch? Derive an expression for discharge through a v-notch.
20. Numericals

MODULE-3: Laminar and turbulent flow

1. What do you mean by 'Viscous flow'
2. Derive an expression for the viscosity distribution for viscous flow through a circular pipe. Also sketch the velocity distribution and shear stress distribution across a section of the pipe.
3. Prove that maximum velocity in a circular pipe for viscous flow is equal to two times the average velocity of the flow.
4. Find the expression for the loss of head of a viscous fluid through a circular pipe.
5. What is Hagen Poisenille's formula? Drive an expression for Hagen Poisenille's formula.
6. Prove that the velocity distribution for viscous flow between two parallel plates when both plates are fixed across a section is parabolic in nature. Also prove that maximum velocity is equal to one and a half times the average velocity. Also derive an expression for drop of head for a given length of pipes.
7. Numericals:
8. What do you understand by the terms: Major energy loss and minor energy losses in pipes?
9. How will you determine the loss of head due to friction in pipes by using I) Darcy formula and ii) Chezy's formula.
10. Derive an expression for loss of head due to i) Sudden expansion of pipe ii) Sudden contraction in pipe, iii) Bend in pipe, iv) pipe fittings and v) an obstruction in pipe.
11. What is a compound pipe? What will be loss of head when pipes are connected in series?
12. Explain the term pipes in parallel. How discharge through the main pipe is increased by connecting pipes in parallel.
13. Describe flow through branched pipes.
14. Numericals

MODULE-4: Flow over bodies:

1. Define the term: drag and lift. Derive its expression.
2. Numericals.
3. What do you understand by the term boundary layer and boundary layer concept?
4. Define Laminal boundary Layer, Laminar sub Layer, boundary layer thickness. Derive an expression for displacement thickness and momentum thickness.
5. Numericals
6. Define the terms dimensional analysis.
7. What do you mean by fundamental Units and derived Units. Prepared a table for fundamental quantity, geometric quantity, kinematics quantity and dynamic quantity and write their symbol and dimensions. Explain the term dimensionally homogeneous equation.
8. What are the methods of dimensional analysis? Describe Rayleigh's method of dimensional analysis.
9. State Bucking ham's π Theorem. Why this theorem is considered superior over the Rayleigh's method for dimensional conalysis?
10. What do you mean by repeating variables? How are repeating variables are selected for dimensional analysis?.
11. Numericals:

MODULE-5: Compressible Flows and Introduction to CFD:

1. Define Charl's law and boys law
2. Define Mach Number, Mach angle, Mach cone.
3. Explain pressure field due to moving source
4. Define stagnation property, normal shok, oblique shock.
5. Derive an expression for stagnation pressure, density and temperature.
6. Numericals
7. Write a note on necessity of CFD.

15.0 University Result

Examination	S+	S	A	B	C	D	E	% Passing
July 2017	00	00	03	10	22	29	27	65.51
July 2018	00	00	09	12	39	19	18	84.90
July 2019								75

Prepared by	Checked by		
Dr. S.N.Topannavar Prof. R.V.Nyamagoud	Module Coordinator	HOD	Principal

Subject Title	KINEMATICS OF MACHINES		
Subject Code	18ME44	IA Marks	40
No of Lecture Hrs + Tutorial Hrs / Week	03+02	Exam Marks	60
Total No of Lecture + Practical Hrs	50	Exam Hours	03
			CREDITS – 04

FACULTY DETAILS:		
Name: Prof. G. V. Chiniwalar	**Designation:** Asst. Professor	**Experience:** 19 Years
No. of times course taught: 04		**Specialization:** Machine Design
Name: Prof. Mahantesh Tanodi	**Designation:** Asst. Professor	**Experience:** 08 Years
No. of times course taught: 07		**Specialization:** Machine Design

1.0 Prerequisite Subjects:

Sl. No	Branch	Semester	Subject
1	Mechanical Engineering	I/II	Elements of Mechanical Engineering
2	Mechanical Engineering	I/II/III/IV	Engg Mathematics
3	Mechanical Engineering	III	Mechanics of Materials

2.0 Course Objectives

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

3.0 Course Outcomes

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

CO	Course Outcome	Cognitive Level	POs	PSOs
C219.1	Identify mechanisms, their motion and understand the inversions of four bar mechanisms.	L2	PO1,PO2, PO6, PO8, PO12	PSO1,PSO2
C219.2	Comprehend velocity and acceleration analysis of planar mechanisms using graphical method, Instantaneous Center Method	L1,L2,L3,	PO1,PO2, PO6, PO8, PO12	PSO1,PSO2
C219.3	Comprehend velocity and acceleration analysis of planar mechanisms using analytical method	L1,L2,L3,	PO1,PO2, PO6, PO8, PO12	PSO1,PSO2
C219.4	Analysis of cam follower motion for the motion specifications.	L2	PO1,PO2, PO6, PO8, PO12	PSO1,PSO2
C219.5	Understand the working of the spur gears and analyze the gear trains speed ratio and torque.	L2,L3,	PO1,PO2, PO6, PO8, PO12	PSO1,PSO2
Total Hours of instruction		**50**		

4.0 Course Content

MODULE -1

Mechanisms: Definitions: Link , types of links, joint, types of joints kinematic pairs, Constrained motion, kinematic chain, mechanism and types , degrees of freedom of planar mechanisms, Equivalent mechanisms, Groshoff's criteria and types of four bar mechanisms, , inversions of of four bar chain, slider crank chain, Doubler slider crank chain and its inversions,

Grashoff's chain. Mechanisms: Quick return motion mechanisms Drag link mechanism, Whitworth mechanism and Crank and slotted lever Mechanism. Straight line motion mechanisms, Peaucellier's mechanism and Robert's mechanism. Intermittent Motion mechanisms: Geneva wheel mechanism, Ratchet and Pawl mechanism, toggle mechanism, pantograph, condition for correct steering, Ackerman steering gear mechanism. **(10 Hours)**

MODULE -2

Velocity and Acceleration Analysis of Mechanisms (Graphical Method): Velocity and acceleration analysis of four bar mechanism, slider crank mechanism. Mechanism illustrating Corioli's component of acceleration. Angular velocity and angular acceleration of links, velocity of rubbing. Velocity

Analysis by Instantaneous Center Method: Definition, Kennedy's theorem, Determination of linear and angular velocity using instantaneous center method. **(10Hours)**

MODULE -3

Velocity and Acceleration Analysis of Mechanisms (Analytical Method): Velocity and acceleration analysis of four bar mechanism, slider crank mechanism using complex algebra method.

Freudenstein's equation for four bar mechanism and slider crank mechanism.

Function Generation for four bar mechanism

MODULE -4

Cams: Classification of cams, Types of followers, Cam nomenclature, Follower motions and motion analysis, of SHM, Motion with uniform acceleration and deceleration, uniform velocity, cycloidal motion, Cam profile with offset knife edge follower, roller follower, flat faced follower.**(10 Hours)**

MODULE -5

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

Gear Trains: Simple gear trains, compound gear trains. Epicyclic gear trains: Algebraic and tabular methods of finding velocity ratio of epicyclic gear trains, torque calculation in epicyclic gear trains. **(10 Hours)**

5.0 Relevance to future subjects

SL. No	Semester	Subject	Topics / Relevance
01	V	Dynamics of Machines	Mechanisms
01	VI	Design of machine element II	Gears/Cams
02	VII	Project Work	Kinematic analysis and synthesis of Mechanical parts

6.0 Relevance to Real World

SL. No	Real World Mapping
01	Kinematic analysis and synthesis of Mechanisms
02	Kinematic analysis and synthesis of Gears

7.0 Books Used and Recommended to Students

Text Books
1.Rattan S.S, Theory of Machines, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 4 th Edition, 2014.
2. Ambekar A. G., Mechanism and Machine Theory, PHI, 2009.
Reference Books
1. Michael M Stanisic, Mechanisms and Machines-Kinematics, Dynamics and Synthesis, Cengage Learning, 2016.
2.Sadhu Singh, Theory of Machines, Pearson Education (Singapore)Pvt. Ltd, Indian Branch New Delhi, 2nd Edi. 2006.
Additional Study material & e-Books
1.Nptel.ac.in
2.VTU, E- learning

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

Website and Internet Contents References
http://www.nptel.ac.in

9.0 Magazines/Journals Used and Recommended to Students

Sl.No	Magazines/Journals	website
1	Mechanism and Machine Theory - Journal - Elsevier	https://www.journals.elsevier.com/mechanism-and-machine-theory
2	Theory of Mechanisms and Machines: electronic journal	tmm.spbstu.ru/english.html
3	Mechanisms and robotics	http://mechanismsrobotics.asmedigitalcollection.asme.org/journal.aspx

10.0 Examination Note

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.

11.0 Course Delivery Plan

Module No.	Lecture No.	Content of Lecture	% of Portion
1		**Mechanisms**	20
	1	Definitions: Link , types of links, joint, types of joints kinematic pairs, Constrained motion, kinematic chain	
	2	Mechanism and types , degrees of freedom of planar mechanisms, Equivalent mechanisms, Groshoff's criteria and types of four bar mechanisms	
	3	Inversions of four bar chain	
	4	Inversions of slider crank chain	
	5	Inversions of double slider crank chain Grashoff's chain	
	6	Mechanisms: Quick return motion mechanisms Drag link mechanism, Whitworth mechanism and Crank and slotted lever Mechanism	
	7	Straight line motion mechanisms,Peaucellier's mechanism and Robert's mechanism	
	8	Intermittent Motion mechanisms: Geneva wheel mechanism, Ratchet and Pawl mechanism	
	9	Toggle mechanism, pantograph,	
	10	Condition for correct steering, Ackerman steering gear mechanism.	
2		**Velocity and Acceleration Analysis of Mechanisms (Graphical Method)**	20
	11	Velocity and acceleration analysis of four bar mechanism,	
	12	slider crank mechanism	
	13	Mechanism illustrating Coriolis component of acceleration	
	14	Angular velocity and angular acceleration of links, velocity of rubbing.	
	15	Velocity Analysis by Instantaneous Center Method: Definition,	
	16	Kennedy's theorem,	
	17	Determination of linear and angular velocity using instantaneous center method.	
	18	Problems	
	19	Problems	
	20	Problems	

3		**Velocity and Acceleration Analysis of Mechanisms (Analytical Method):**	20
	21	Velocity and acceleration analysis of four bar mechanism using complex algebra method	
	22	slider crank mechanism using complex algebra method	
	23	slider crank mechanism using complex algebra method	
	24	Freudenstein's equation for four bar mechanism	
	25	Freudenstein's equation for slider crank mechanism.	
	26	Function Generation for four bar mechanism.	
	27	Problems	
	28	Problems	
	29	Problems	
	30	Problems	
4		**Cams:**	20
	31	Classification of cams, Types of followers, Cam nomenclature,	
	32	Follower motions and motion analysis, of SHM,	
	33	Motion with uniform acceleration and deceleration, uniform velocity, cycloidal motion,	
	34	Motion with uniform acceleration and deceleration, uniform velocity, cycloidal motion.	
	35	Problems	
	36	Problems	
	37	Problems	
	38	Problems	
	39	Problems	
	40	Problems	
5		**Spur Gears:**	20
	41	Gear terminology, law of gearing	
	42	Path of contact, arc of contact, contact ratio of spur gear	
	43	Interference in involute gears, methods of avoiding interference,	
	44	Condition and expressions for minimum number of teeth to avoid interference	
	45	Solving of related numerical	
	46	**Gear Trains:** Simple gear trains, compound gear trains. Epicyclic gear trains	
	47	Algebraic methods of finding velocity ratio of epicyclic gear trains,	
	48	Solving of related numerical.	
	48	Tabular methods of finding velocity ratio of epicyclic gear trains,	
	49	Solving of related numerical.	
	50	Solving of related numerical.	

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 & Mechanisms	Explain Basic definitions and Mechanisms	Module 1	2	Individual Activity.	Text Book 1&2
2	*Assignment-2:* Questions on Velocity and Acceleration Analysis of Mechanisms (Graphical Method)	Analyses Velocity and Acceleration of Mechanisms by Graphical Method.	Module 2	4	Individual Activity.	Text Book 1&2
3	*Assignment-3:* Questions on Velocity and Acceleration Analysis of Mechanisms (Analytical Method)	Analyses Velocity and Acceleration of Mechanisms by Analytical Method.	Module 3	6	Individual Activity.	Text Book 1&2
4	*Assignment-4:* Cams	Explain types of cams their terminology & Analysis of cams	Module 4	8	Individual Activity.	Text Book 1&2
5	*Assignment-5:* Questions on Spur gears & gear trains	Explain Gear terminology & types of gears	Module 5	8	Individual Activity.	Text Book 1&2

13.0 QUESTION BANK

MODULE-1:
INTRODUCTION:

1. Define kinematic link, kinematic pair, and kinematic chain.
2. Distinguish between a) mechanism and machine b) completely constrained motion and successful constrained motion.
3. What is an inversion? Explain various inversions of single and double slider crank chains.
4. Discuss various types of constrained motions.
5. What are quick-return mechanisms? Where are they used? Discuss the functioning of any one of them.
6. Explain briefly elliptical trammel and scotch yoke mechanism with neat diagram.
7. Define mobility of a mechanism with example.
8. What is the difference between exact and approximate straight line mechanism. Explain each with suitable example.
9. Explain the working of the following mechanisms with neat sketch a) pantograph b) toggle mechanism c) Ackermann's steering gear mechanism d) Geneva mechanism e) Ratchet and pawl mechanism.
10. Explain the following mechanisms with suitable sketches a) drag link mechanism b) whit worth mechanism c) crank and slotted link mechanism.

MODULE-2:
VELOCITY AND ACCELERATION ANALYSIS OF MECHANISMS (GRAPHICAL METHODS):

1. In mechanism shown in fig.2.1, crank2 rotates at 3000rpm.Find the acceleration of the point C in magnitude, direction and sense. Find also the angular acceleration of link 3.

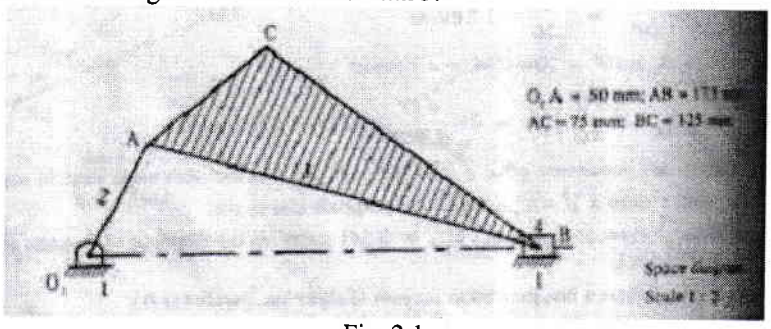

Fig. 2.1

2. The crank of a slider crank mechanism is 480mm long and rotates at 20 rad/sec in the counter clockwise direction. It has a connecting rod of 1600mm long. Determine the following when the crank is 60 degree from the inner dead centre, angular velocity of the connecting rod, the position and the velocity of a point P on the connecting rod having least absolute velocity shown in the fig.2.2

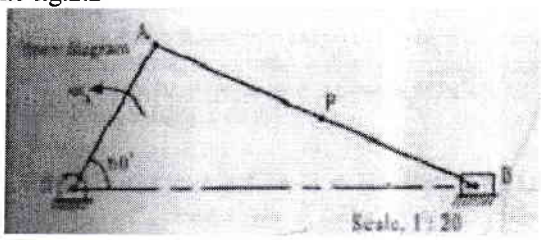

Fig. 2.2

3. The crank O2A of four bar mechanism shown in fig.2.3, is rotating clockwise at a constant speed of 100 rad/sec. Determine(a)The acceleration of the point C (b)The angular acceleration of the links 3&4.

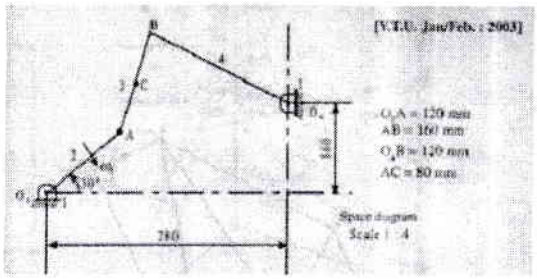

Fig. 2.3

32

4. A four bar mechanism ABCD is made up of four links, pin jointed at the ends. AD is fixed link which is 180 mm long. The links AB, BC, CD are 90 mm, 120mm and 120mm respectively. At certain instant, the link AB makes an angle of 60 degree with the link AD, if the link AB rotates at uniform speed of 100 rpm clockwise determine angular velocity of links BC and CD and angular acceleration of link CD and CB as shown in fig 2.4

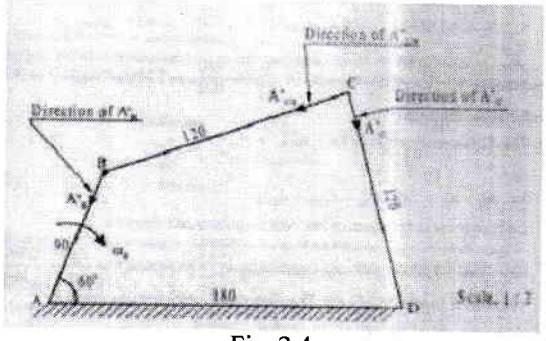

Fig. 2.4

5. In a slider crank mechanism, the crank OB = 30mm and the connecting rod BC=120mm. the crank rotates at uniform speed of 300rpm clockwise. Find the crank position shown in the figure in which the crank is turned 60 degree, find a) velocity of piston C and angular velocity of connecting rod BC b) acceleration of piston C and angular acceleration of connecting rod BC as shown in fig 2.5

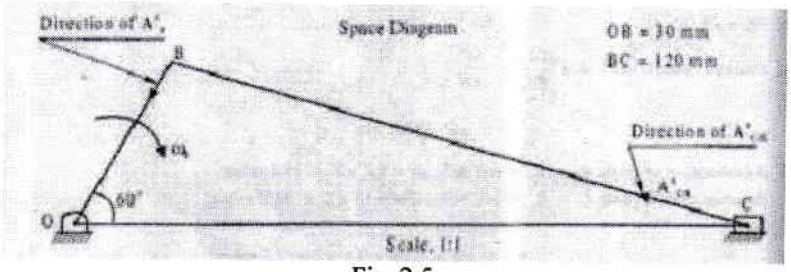

Fig. 2.5

VELOCITY ANALYSIS BY INSTANTANEOUS CENTER METHOD:

1. State and prove Arnold-Kennedy theorem of three centers or three centers inline theorem with a neat diagram.
2. Locate all the instantaneous centers for the four bar mechanism shown in the figure as shown in fig.2.6

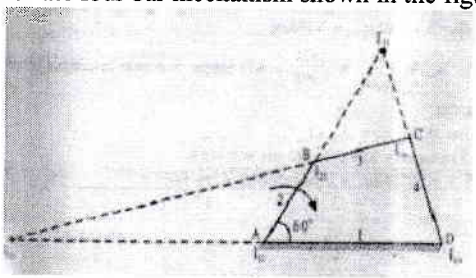

Fig. 2.6

3. Locate all the instantaneous centers for the slider and crank mechanism shown in the fig.2.7

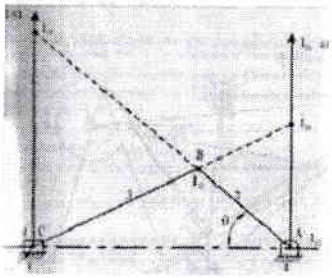

Fig. 2.7

4. In a four bar mechanism shown in fig 4.4,link 2 is rotating at angular velocity ω2.locate all the instantaneous centers of the mechanism &find a) the angular speeds of link 3 & 4, the linear velocity of links 3 & 4, the linear velocities of points E & F as shown in the figure 2.8

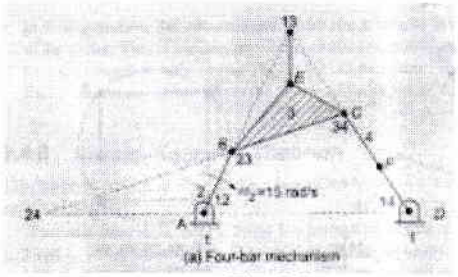

Fig. 2.8

5. Locate all the instantaneous centers of the mechanism shown in the figure 2.9

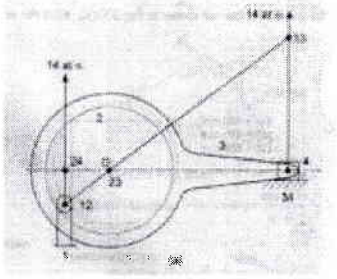

Fig. 2.9

MODULE-3:

VELOCITY AND ACCELERATION ANALYSIS OF MECHANISMS (ANALYTICAL METHODS):

1. If the crank and connecting rod are 150 mm and 600 mm long respectively and the crank rotates at a constant speed of 100 rpm, determine a) velocity and acceleration of the piston b) angular velocity c) and angular acceleration of the connecting rod. The angle which the crank makes with the inner dead centre is 30 degrees.
2. The length of the connecting rod of a gas engine running at 340 rpm is 600mm and the crank is 120mm long. When the piston has moved one fourth stroke during out stroke determine a) then angular position of the crank b) the angular speed of connecting rod and c) the acceleration of the piston.
3. The length of the crank of a reciprocating engine is 120mm and its connecting rod length is 600mm it rotates at 360 rpm and at a particular instant it makes an angle of 50 degree with the inner dead center. Find a) velocity and acceleration of the piston b) velocity and acceleration of the midpoint of the connecting rod c) angular velocity and angular acceleration of the connecting rod.

MODULE-4:

CAMS:

1. Enumerate commonly used types of cams.
2. Discuss briefly the types of follower displacement diagrams
3. Define the following terms related to cam (a)Lift (b)Dwell (c)Pressure angle (d)Base circle
4. Explain the following types of cams (a)D-R-D cam (b)D-R-R-D cam (c)R-R-R cam.
5. Draw the profile of the cam operating a roller reciprocating follower with the following data: minimum radius of the cam==25mm,lift==30mm,roller diameter==15mm.The cam lifts the follower for 120degree with SHM followed by a dwell period of 30degree.Then the follower lowers down during 150degree of the cam rotation with uniform acceleration and deceleration followed by a dwell period .If the cam rotates at uniform speed of 150rpm,calculate the maximum velocity and acceleration of the follower during decent period.
6. A flat faced follower is raised through a distance of 25mm is 120degree rotation of the cam, remains at rest for the next 30degree and is lowered during further 120degree rotation of the cam. The raising of the follower takes place with cycloidal motion and the lowering with uniform acceleration and deceleration. However, the uniform acceleration is 2/3 of the uniform deceleration .The least radius of the cam is 25mm.Draw the cam profile assuming clockwise rotation of the cam.
7. Draw the profile of the cam to give the following motion to the follower: Follower to move through 30mm during 180degree of cam rotation with cycloidal motion .Follower to return with cycloidal motion during 180degree of cam rotation .Base circle radius of the cam is30mm&the roller diameter of the follower is 10mm.The axis of the roller is offset by 8mm to the right. .Determine the maximum velocity& acceleration of the follower during the out stroke, when the cam rotates at 2000rpm.

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MODULE-5:

SPUR GEARS:

1. Two spur gears have 24 and 30 teeth of module =10mm, standard addendum=1 module, pressure angle=20 degrees find a) length of arc of contact b) contact ratio.
2. Two mating gears with module pitch 6mm have 20 and 50 teeth of pressure angle 20 degrees and addendum 6mm. Determine the number of pairs of teeth in contact.
3. A pinion of 24 teeth drives a gear of 60 teeth at a pressure angle of 20 degrees. The pitch radius of pinion is 38mm and outside radius is 41mm. The pitch radius of the gear is 95mm and the outside radius 98.5mm. Calculate the length of path of contact and contact ration.
4. Two 20 degrees involute gears in mesh have a gear ratio of 2 and 20 teeth on the pinion. The module is 5mm and the pitch line speed is 1.5 mtr per second. Assuming addendum to be equal to 1 module find a) angle turned through by pinion when one pair of teeth is in mesh and b) maximum velocity of sliding.
5. Two spur gears have 30 teeth each of involute shape. The circular pitch is 25mm. Pressure angle=20 degrees, determine the addendum of wheels if arc of contact is twice the circular pitch.
6. Two gear wheels mesh externally and are to give velocity ratio of 3. The teeth are of involute form of module 6mm and standard addendum=1module. Pressure angle=18 degrees, pinion rotates at 90 rpm. Find a) number of teeth on each wheel so that interference is just avoided b) length of path of contact c) maximum velocity of sliding between teeth.
7. Find the minimum number of teeth to avoid under cutting when the addendum for teeth is 0.84 module. Gear ratio is 3:1; find the length of arc of contact in terms of module. Pressure angle=20 degrees.
8. Two gears in mesh have a module of 8mm and a pressure angle of 20 degree. The larger gear has 57 teeth while pinion has 23 teeth. If the addenda on pinion and gear wheel are equal to 1module find a) the number of pairs of teeth in contact the angle of action of the pinion and the gear wheel.

GEAR TRAINS:

1. Two spur gears A & B of an Epicyclic gear train is shown in the figure 4.1 have 24 and 30 teeth respectively. The arm rotates at 100 rpm clockwise. Find the speed of gear B on its own axis when gear A is fixed. If instead of being fixed the wheel A rotates at 200 rpm in ccw direction, what will be the speed of gear B. (solve it by algaebraic method)

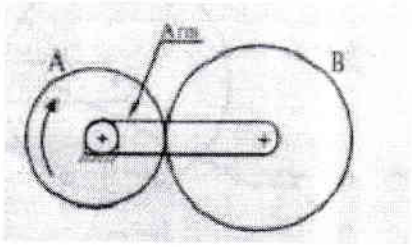

Fig. 4.1

2. In an Epicyclic gear train shown in the figure 4.2, the arm A is fixed to the shaft S the wheel B having 100 teeth rotates freely on the shaft S , wheel F 150 teeth is separately driven. If the arm A runs at 200 rpm, wheel F at 100 rpm in the same direction find a) number of teeth of gear C b) speed of the wheel B. (solve it by algebraic method)

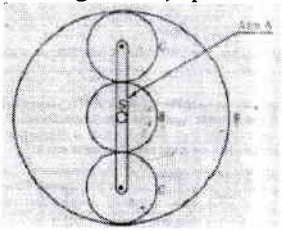

Fig. 4.2

3. A fixed annular wheel B has 92 teeth. Wheel C and D have 25 and 15 teeth respectively. Wheel E has 52 teeth, if the arm A rotates at 130 rpm, what is the speed of wheel E shown in the figure 4.3.(solve it by algaebraic method)

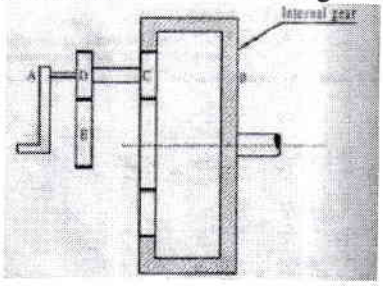

Fig. 4.3

4. The gear train shown in the fig.3.4.Gear A meshes with gear B.In the compound gear B-C, gear C meshes with gear D, Rotating relative to A around the same axis of A. If the gear A is fixed, arm F is used as the driving member, determine the speed ratio n_D/n_F. Number of teeth on wheels A,B,C&D are 61,61,62&60 respectively(solve it by graphical method.)

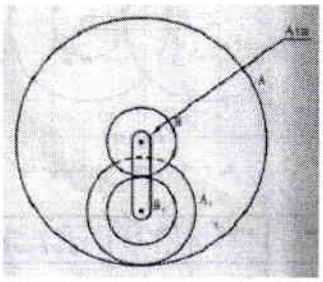

Fig. 4.4

5. An Epicyclic gear train is constructed as shown in fig 4.5.A fixed annular wheel A & a smaller concentric wheel B are connected by a compound wheel A_1-B_1,A_1 gearing with A. B_1 gearing with B. The compound wheel revolves on a stud which is carried around an arm which revolves about the axis A&B.A has 130 teeth,B1=80 teeth, pitch of A&A_1 being twice that of pitch of B&B_1.How many revolutions B will make for one revolution of the arm. (solve it by algebraic method)

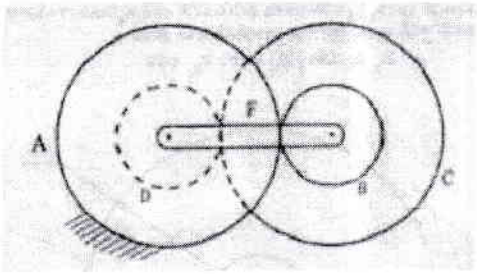

Fig. 4.5

6. An Epicyclic gear train is shown in the fig. 4.6.The wheel A is fixed& the input at the arm R is 3KW at 600rpm.Find the speed of wheel D and the torque required to hold the wheel A. Neglect frictional losses. (solve it by algebraic method)

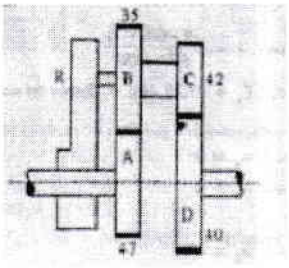

Fig. 4.6

7. In Epicyclic gear train shown in the fug 4.7, wheels A, D, E are free to rotate independently on the spindle O, while the compound wheel B-C rotates on the spindle P on the arm OP .If wheel A is given clockwise revolution of 60rpm, while gear D is given counterclockwise revolution at 300rpm,Determine the magnitude and direction of speeds of arm OP and wheel E.

Wheel	A	B	C	D	E
Teeth	12	30	14	?	?

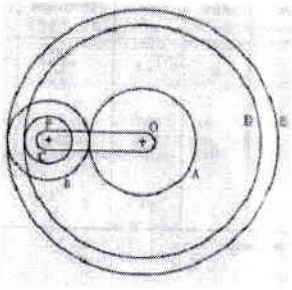

Fig. 4.7

8. Explain the term train value and velocity ratio used in gear trains.
9. Explain different types of gear trains with neat sketches and give examples where each one is used in practice.
10. Explain the sketches (a) Compound gear train (b) Reverted gear train (c) Epicyclic gear train.

14.0 University Result

Examination	S+	S	A	B	C	D	E	% Passing

Prepared by	Checked by		
Prof.Mahantesh Tanodi	Prof.G. V. Chiniwalar	11/02/2020 HOD	Principal

Subject Title	Metal Casting and Welding		
Subject Code	18ME45A	IA Marks	40
No of Lecture Hrs + Practical Hrs / Week	03	Exam Marks	60
Total No of Lecture + Practical Hrs	50	Exam Hours	03
CREDITS – 04			

FACULTY DETAILS:		
Name: Prof. R.K Chitgopkar	Designation: Asst. Professor	Experience: 30 Years
No. of times course taught: 04	Specialization: TPE	

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	Know 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	
1.	http://www.nptel.ac.in
2.	http://me.emu.edu.tr/me364/2.pdf
3.	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 16 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,	

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	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: students able to	Allied study	Week No.	Individual / Group activity	Reference: book/website /Paper
1	Assignments will be given at the end of the each module covering all the important and (un)covered portions.					

12.0 QUESTION BANK

Sample Questions	Questions
I	**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.
II	**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.

III	**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.
IV	**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.
V	**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?

13.0 University Result

Examination	FCD	FC	SC	% Passing
2017/18	20	15	22	100
2016/18	13	17	29	95.89

Prepared by	Checked by		
Prof. R.K.Chitgopkar	Prof. G A Naik	HOD Mechanical Engg. HIT, Nidasoshi HOD	Principal

Subject Title	MECHANICAL MEASUREMENTS AND METROLOGY		
Subject Code	18ME36B/46B	**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. G A Naik	**Designation:** AP	**Experience:24 years**
No. of times course taught:22	**Specialization:** Production Technology	

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**	

45

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

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

9.0 Magazines/Journals Used and Recommended to Students

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

10.0 Examination Note

Internal Assessment:
Theoretical aspects as well as relevant sketches should be drawn neatly for questions asked in Internal Assessments
Scheme of Evaluation for Internal Assessment (40 Marks)
(a) 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	1	Definition, objectives and concept of metrology	20%
	2	Need of inspection, Principles, process,	
	3	methods of measurement, Classification and selection of measuring instruments and systems	
	4	Accuracy, precision and errors in measurement	
	5	System of measurement, Material Standard, Wavelength Standards, Subdivision of standards,	
	6	Line and End standards, Classification of standards and Traceability, calibration of End bars(Numerical), standardization	
	7	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,	
	8	care of slip gauge, slip gauge accessories, problems on building of slip gauges (M87, M112) Auto collimator-applications for measuring straightness and squareness	
2	9	Definition of tolerance, Specification in assembly, Principle of interchangeability and selective assembly	40%
	10	limits of size, Indian standards, concept of limits of size and tolerances,	
	11	definition of fits, hole basis system, shaft basis system, types of fits and their designation (IS 919-1963),	
	12	Geometric tolerance, position-tolerances. Classification of gauges, brief concept of design of gauges (Taylor's principles),	
	13	Wear allowance on gauges, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials.	
	14	Functional requirements, classification	
	15	mechanical- Johnson Mikrokator, sigma comparators	
	16	dial indicator, electrical principles, , LVDT, Pneumatic- back pressure gauges, solex comparators optical comparators- Zeiss ultra-optimeter	
3	17	Terminology of screw threads, measurement of major diameter	60%
	18	minor diameter, pitch, angle and effective diameter of screw threads by 2-wire and 3- wire methods,	

	19	best size wire. Screw thread gauges, Tool maker's microscope. Gear tooth terminology, tooth thickness measurement using constant chord method,	
	20	addendum comparator method and base tangent method, measurement of pitch	
	21	Concentricity, run out, and involute profile. Gear roll tester for composite error	
	22	Basic concepts of lasers, advantages of lasers	
	23	laser interferometers, types	
	24	applications. Basic concepts of Coordinate Measuring Machines constructional features, applications, constructional features, applications	
4	25	Definition, significance of measurement, generalized measurement system	80%
	26	definitions and concept of accuracy, precision, calibration,	
	27	threshold, sensitivity, hysteresis, repeatability, linearity, loading effect, system response-time delay. Errors in measurement,	
	28	Classification of errors. Transducers, transfer efficiency, primary and secondary transducers,	
	29	Mechanical, electronic transducers, advantages of each type transducers.	
	30	Mechanical systems, inherent problems	
	31	electrical intermediate modifying devices	
	32	input circuitry, ballast circuit, Electronic amplifiers. Terminating devices Cathode ray oscilloscope, Oscillographs	
5	33	Direct methods and indirect method	100%
	34	force measuring inst. Torque measuring inst., Types of dynamometers, Absorption dynamometer	
	35	Prony brake and rope brake dynamometer, and power measuring instruments.	
	36	Pressure measurement, principle, use of elastic members	
	37	Bridgeman gauge, McLeod gauge, Pirani gauge.	
	38	Theory of strain gauges, types, electrical resistance strain gauge, preparation and mounting of strain gauges,	
	39	Gauge factor, methods of strain measurement. Temperature Compensation, Wheatstone bridge circuit,	
	40	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?

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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

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

Subject Title	Mechanical measurements and Metrology Laboratory		
Subject Code	18MEL37B / 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. G A Naik	**Designation:** Asst. Professor	**Experience:**24Years
No. of times course taught: 22 Times	**Specialization:** Production Technology	

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
1. 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

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Notes/Animation/Videos Recommended

Website and Internet Contents References
1. http://www.tatynerds.com/mechanical-metrology-metrology
2. http: //www.vturesource.com/2011/01/mechanical-measurements
3. http://www.nptel.ac.in
4. http://www.sapnaonline.com/shop/Author/t-chandrashekar

9.0 Magazines/Journals Used and Recommended to Students

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

10.0 Examination Note

Internal Assessment:
Theoretical aspects as well as relevant sketches should be drawn neatly for questions asked in Internal Assessments
Scheme of Evaluation for Internal Assessment (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.	

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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. G A Naik	Prof. S R. Kulkarni	HOD 12.2.2020	Principal

Subject Title	**FOUNDRY, FORGING & WELDING LAB**		
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:** 16Years
No. of times course taught: 05 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

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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

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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 2017-18	60	1	1	100

Prepared By	Checked By		
Mr .M. S Futane **Course coordinator**	G. A Naik **Module coordinator**	13.02.2020 **HOD**	**Principal**