B.L.D.E.A's

Vachana Pitama Dr.P.G.Halakatti College of Engineering & Technology, Bijapur-03

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE FILE

Semester – IV

2017-18

B.L.D.E.A's

V.P. Dr. P.G.H. College of Engineering & Technology Bijapur-03

Department of Mechanical Engineering

2017-18 Even sem

IV SEMESTER

INDEX

COURSE: Engineering Mathematics - IV

Semester: IV **Year: 2017-18 (Even Semester)**

Subject Code: 15MAT41 **IA Marks: 20**

Total Contact Hours: 50 hrs **Hours per week: 4**

VTU Exam Marks: 80 **Exam: 3 Hours**

1. Syllabus:

MODULE	Levels	No. of hrs
MODULE-I **Numerical Methods**: Numerical solution of ordinary differential equations of first order and first degree, Taylor's series method, modified Euler's method, Runge - Kutta method of fourth order. Milne's and Adams-Bashforth predictor and corrector methods (No derivations of formulae).	**L2 & L3**	10
MODULE-II **Numerical Methods**: Numerical solution of second order ordinary differential equations, Runge- Kutta method and Milne's method. **Special Functions**: Series solution-Frobenious method. Series solution of Bessel's differential equation leading to $J_n(x)$-Bessel's function of first kind. Basic properties, recurrence relations and Orthogonality. Series solution of Legendre's differential equation leading to $P_n(x)$-Legendre Polynomials. Rodrigue's formula, problems	**L2 & L3**	10
M**ODULE-III** **Complex Variables:** Review of a function of a complex variable, limits, continuity and differentiability. Analytic functions, Cauchy-Riemann equations in Cartesian and polar forms. Properties and construction of analytic functions. Complex line integrals-Cauchy's theorem and Cauchy's integral formula, Residue, poles, Cauchy's Residue theorem (without proof) and problems. **Transformations:** Conformal transformations, discussion of transformations $W = Z^2, W = e^z, W = z + \left(\frac{1}{z}\right)\ (z \neq 0)$ and bilinear transformations-Problems	**L2 & L3** **L4**	10
MODULE-IV **Probability Distributions:** Random variables(discrete and continuous), Probability mass/density functions. Binomial distribution, Poisson distribution, Exponential and normal distributions, Problems. **Joint probability distribution:** Joint Probability distribution for two discrete random variables, expectation, covariance, correlation coefficient.	**L3**	10
MODULE-V **Sampling Theory:** Sampling, Sampling distributions, standard error, test of	**L3 & L4**	10

hypothesis for means and proportions, confidence limits for means, student's t-distribution, Chi-square distribution as a test of goodness of fit. **Stochastic process:** Stochastic process, probability vector, stochastic matrices, fixed points, regular stochastic matrices, Markov chains, higher transition probability simple problems.		

Course Outcomes:

1. Use appropriate single step and multi-step numerical methods to solve first and second order ordinary differential equations arising in flow data design problems.
2. Explain the idea of analyticity, potential field's residues and poles of complex potentials in field theory and Electromagnetic theory.
3. Employ Bessel's functions and Legendre's polynomials for tackling problems arising in continuum mechanics, hydrodynamics and heat conduction.
4. Describe random variables and probability distributions using rigorous statistical methods to analyze problems associated with optimization of digital circuits, information, coding theory and stability analysis of systems.
5. Apply the knowledge of joint probability distributions and Markov chains in attempting engineering problems for feasible random events.

Question paper pattern:

Question paper pattern:

- The question paper will have **ten** full questions carrying equal marks.
- Each full question consisting of **16** 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.

Graduate Attributes (as per NBA)

1. Engineering Knowledge
2. Problem Analysis
3. Life-Long Learning
4. Accomplishment of Complex Problems

Text Books:

1. B.S. Grewal: Higher Engineering Mathematics, Khanna Publishers, 43rd Ed., 2015.

2. E. Kreyszig: Advanced Engineering Mathematics, John Wiley & Sons, 10th Ed., 2015.

Reference books:

1. N.P.Bali and Manish Goyal: A Text Book of Engineering Mathematics, Laxmi Publishers, 7th Ed., 2010.

2. *B.V.Ramana: "Higher Engineering Mathematics" Tata McGraw-Hill, 2006.*

3. *H. K. Dass and Er. RajnishVerma: "Higher Engineering Mathematics", S. Chand publishing, 1st edition,2011.*

We links and Video Lectures:

1. http://nptel.ac.in/courses.php?disciplineID=111

2. http://wwww.khanacademy.org/

3. http://www.class-central.com/subject/math

2. Prerequisites of the course:

To learn this subject, the student must have the knowledge about differentiation integration, set theory, permutation & combination and probability.

3. Overview of the course:

The primary goal of this course is to highlight the essential concepts of i) numerical methods ii) complex variables iii) series solutions of differential equations iv) probability

Many differential equations of interest to engineers are not amenable to analytical solutions and hence we must resort to numerical solutions. Also the rapid development of high speed digital computers and the

Increasing desire for numerical answers to applied problems has led to the enhanced demands in the methods and techniques of numerical analysis.

Complex variables are useful in the study of fluid mechanics, thermodynamics, electric fields, aerodynamics, elasticity etc. Conformal mapping, which preserves angles in magnitude and sense, is useful in solving boundary value problems in two dimensional potential theory by transforming a complicated region to a simpler region.

The solutions to differential equations with variable co-efficient cannot be expressed as finite linear combination of known elementary functions, however in such cases solutions can be obtained in the form of infinite power series. In series solutions of differential equations with variable co-efficients we use power series method.

Probability is the measure of how frequently the same event occurs in an experiment. The study of probability provides a mathematical frame work to asses the chances of the predictions coming true and is essential in every decision making process.

Probability distribution is the theoretical counter part of frequency distribution, and plays an important role in the theoretical study of populations. Ex: The shoes industry should know the sizes of foot of the population. Sampling aims at gathering the maximum information about the population with the minimum effort, time and cost.

Stochastic process: Stochastic process technique, probability vector, stochastic matrices, fixed points, regular stochastic matrices, Markov chains, higher transition probability

4. Relevance of the course to this program:

<u>Numerical Methods:</u>

Numerical techniques are applicable for determining the motion of a body falling through a viscous fluid arising in a wide variety of engineering contexts.

<u>Complex variables:</u>

In the theory of alternating current, the application of complex impedance involves functions having complex numbers as independent variables. The theory of complex variables has made a significant contribution in the design of aerofoil sections for aircraft and other lifting bodies. The

strength of the theory in such applications is its ability to generate mappings which transforms complicated shapes, such as an aerofoil section into a simpler shape.

Complex Integration:

To express a complex function as a Taylor's series is applicable in the field of Control and communications theory

Series Solution of ordinary differential equations and special functions :

Heat equation, wave equation and Laplace's equation with cylindrical symmetry can be solved in terms of Bessel's functions, with spherical symmetry by Legendre's polynomials.

Probability distributions:

Probability distributions are applicable for problems concerning i) Radar detection ii) Number of rounds fired from a gun hitting a target. iii) Defective vehicles in a workshop. iv) Telephone calls. v) Errors made by chance in experimental measurements. vi) Reliability and queuing theory.

Joint Probability: Problems in Economics, Biology or social science needs statistical method analyzing two or more variables in such cases the concept of joint probability required.

Sampling:

It is quite often necessary to draw some valid conclusions concerning a large mass of population which is practically impossible and therefore it is preferred to examine a small part of the population called Sample with the motive of drawing some conclusion about the entire population.

Stochastic Process: Stochastic process can be used to analyze and solve diver's range of problems arising in production and inventory control, resource planning, service systems computer networks and many others.

5. Course Outcomes:

1. On completion of this course, students are able to use appropriate numerical methods to solve first and second order ordinary differential equations.
2. Use Bessel's and Legendre's function which often arises when a problem possesses axial and spherical symmetry, such as in quantum mechanics, electromagnetic theory, hydrodynamics and heat conduction.
3. State and prove Cauchy's theorem and its consequences including Cauchy's integral formula compute residues and apply the residue theorem to evaluate integrals.
4. Analyze, interpret, and evaluate scientific hypotheses and theories using rigorous statistical methods

5. Application area: Computer science, Psychology, Agriculture, Geography, Radar detection and
Thermodynamics.

7. Module wise plan:

Module - 1	**Title : Numerical Methods**	**Planned Hours: 08**

Learning Objectives: At the end of this chapter student should be able to

1. Recall the various formulae
2. Apply the appropriate formulas to solve the differential equations with initial conditions.
3. Interpret the one step methods to solve the differential equations with one initial condition and using successive integrations.
4. Interpret the multistep methods to solve the differential equations with more than one initial condition.
5.Apply Milne's and Adams-Bashforth's methods to solve the differential equations with one initial condition after using one step method to get the required number of initial conditions.
6. Evaluate the predicted value of y at x_{n+1} and then correct it using the corrector formula.

Lesson Plan:

Lecture no.	**Topics covered**	**Teaching Method**	**PSOs**	**POs Attained**	**COs Attained**	**Ref Book/ Chapter no.**
L1	Numerical solution of ordinary differential equations of first order and first degree. Examples on Taylor's series method	Chalk and Board	1	1, 2, 4, 5, 11	1	T1/32, T2/21
L2	Some more examples on Taylor's series method					
L3	Euler's formula & Modified Euler's formula- examples					
L4	Some more examples on Modified Euler's method					
L5	Runge-Kutta method of fourth order-examples					
L6	Milne's predictor and corrector method-examples					
L7	Some more examples on Milne's method					
L8	Adams-Bashforth predictor and corrector method-examples					

Assignment questions	COs Attained

1. Using Taylor's series method, compute the solution of:

a) $\frac{dy}{dx} = x + y$, y(0) = 1 at the point x = 0.2 correct to three decimal places.

Module – 2	Title : Numerical Methods	Planned Hours: 12

b) $\frac{dy}{dx} = x - y^2$, y(0) = 1 at the point x = 0.1

c)the initial value problem $\frac{dy}{dx} = 2y + 3e^x$, y(0)=0, at x = 0.1 and x = 0.2

d) $dy = (xy - 1)dx$, y = 2 at x =1 at the point x = 1.02

e) $y' = x^2 + y$ in the range $0 \le x \le 0.2$ by taking step size h= 0.1 ,given that

y = 10 at x = 0, initially considering terms up to the fourth degree.

f) $\frac{dy}{dx} = x^2 + y^2$, y(0) = 0 at the point x = 0.4 correct to three decimal places.

2. Using Euler's modified method, obtain a solution of the equation

a) $\frac{dy}{dx} = x + |\sqrt{y}|$, with initial conditions y =1 at x = 0 , for the range 0<x<0.6 in steps of 0.2. **1**

b) $\frac{dy}{dx} = -xy^2$ y = 2 at x = 0 Obtain 'y' at x = 0.2 in two stages of 0.1 each.

c) $\frac{dy}{dx} = x - y^2$, y(0) = 1 taking h = 0.1, find y(0.2) correct to four decimal places

d) $\frac{dy}{dx} = \log_{10}\left(\frac{x}{y}\right)$, with y(20) = 5 ,taking h = 0.2. Find y(20.2) and y(20.4)

e) $\frac{dy}{dx} = x^2 + y$, y(0) = 1 taking h = 0.05, find y(0.1) considering the accuracy up to two approximations in each step.

3. Employ Runge-Kutta method of fourth order to solve the equation

a) $\frac{dy}{dx} = 3x + \frac{y}{2}$, y(0) = 1 at x = 0.2 taking step length h = 0.2.

b) $10\frac{dy}{dx} = x^2 + y^2$, and y(0)=1 , compute y(0.2) (Take h=0.2)

c) $\frac{dy}{dx} = \frac{y - x}{y + x}$ y(0)=1 , compute y(0.2) (Take h=0.2)

d) $(x + y)\frac{dy}{dx} = 1$ y(0.4) = 1 at x = 0.5

4. Using Milne's method and Adams–Bashforth's predictor- corrector method, solve

a) Given $\frac{dy}{dx} = x - y^2$ and the data Find y(0.8)

X:	0	0.2	0.4	0.6
Y:	0	0.02	0.0795	0.1762

b) Given that $\frac{dy}{dx} = x^2 + \frac{y}{2}$, and y(1)=2,

c) Given $\frac{dy}{dx} = 2e^x - y$ and the data

X:	0	0.1	0.2	0.3
Y:	2	2.010	2.040	2.090

Learning Objectives: At the end of this chapter student should be able to

1.	**Recall** the various formulae
2.	**Apply** the appropriate formulas to solve the second order ordinary differential equations with initial conditions.
3.	**Solve** the Bessel differential equation in series, Recurrence relations
4.	**Solve** the Legendre differential equation in series.
5.	**Apply** Rodrigue's formula to evaluate Legendre polynomials.

Lesson Plan:

Lecture no.	Topics covered	Teaching Method	PSOs	POs attained	COs attained	Ref Book/ Chapter no.
L09	Numerical solution of second order ordinary Differential equations- Runge-Kutta method-examples	Chalk and Board	1	1, 2, 4, 5, 11	2	T1/3 2T2/ 21,5
L10	Milne's method- Examples					
L11	Series solution –Frobenious method					
L12	Series solution of Bessel differential equation leading to $J_n(x)$-Bessel's function of first kind					
L13	Basic properties, and examples					
L14	Some more Examples					
L15	Recurrence relations.					
L16	Orthogonality					
L17	Series solution of Legendre Differential equation leading to $P_n(x)$					
L18	Legendre polynomials					
L19	Examples					
L20	Rodrigue's formula					

Assignment questions:

Assignment questions	COs Attained
1. Using Runge-Kutta method find third approximation to the values a) $y'' = xy'^2 - y^2$ for x = 0.2 correct to four decimal places. Initial conditions are x = 0, y = 1, y' = 0 b) $\frac{d^2y}{dx^2} = x^3\frac{dy}{dx} + x^3y$, given y(0) = 1 , y′ (0) = ½	

c) $\frac{d^2y}{dx^2} = x\frac{dy}{dx} - y$ given that y = 1, $\frac{dy}{dx} = 0$ when x = 0

d) $\frac{d^2y}{dx^2} = x\left(\frac{dy}{dx}\right)^2 - y^2$ given that y = 1, $\frac{dy}{dx} = 0$ when x = 0

2. The angular displacement of θ of a simple pendulum is given by the equation $\frac{d^2\theta}{dt^2} + \frac{g}{l}\sin\theta = 0$, where l = 98 cm and g = 980 cm/sec^2, if θ = 0 and $\frac{d\theta}{dt} = 4.472$ at t = 0, use Runge-Kutta method to find θ.

3. Given y″ + xy′ + y = 0, y(0) = 1 , y′(0) = 0, obtain y for x = 0(0.1)0.3 by any method. Further, continue the solution by Milne's method to calculate y (0.4). 2

4. Applying Milne's method compute $y(0.8)$ given that y satisfies the equation $y'' = 2yy'$ and y & y' are governed by the fallowing values

x	0	0.2	0.4	0.6
y	0	0.2027	0.4228	0.6841
y'	1	1.041	1.179	1.468

5. Apply Milne's method to compute y (0.4) given the equation $y'' + y' = 2e^x$

And the following table of initial values.

x	0	0.1	0.2	0.3
y	2	2.01	2.04	2.09
y'	0	0.2	0.4	0.6

6. Use Frobenius method to solve the equations
a) 3xy″ + 2y′ + y = 0 b) 4xy″ + 2(1-x)y′ - y = 0

7. Solve Bessel's differential equation leading to $J_n(x)$.

8. Prove

a) $\frac{d[x^n J_n(x)]}{dx} = x^n J_{n-1}(x)$ b) $\frac{d[x^{-n} J_n(x)]}{dx} = -x^{-n} J_{n+1}(x)$

c) $J_{1/2}(x) = \sqrt{\frac{2}{\pi x}}\sin x$ d) $J_{-1/2}(x) = \sqrt{\frac{2}{\pi x}}\cos x$

2

9. Prove $2nJ_n(x) = x[J_{n+1}(x) + J_{n-1}(x)]$

10. Prove $\frac{d}{dx}[x^n J_n(x)] = x^n J_{n-1}(x)$

11. Prove that $\int_0^1 x J_n(\alpha x) J_n(\beta x)\,dx = \begin{cases} 0 & \alpha \neq \beta \\ \frac{1}{2}\left[J_{n+1}(\alpha)\right]^2 & \alpha = \beta \end{cases}$ where α, β are the roots of $J_n(x) = 0$

12. Solve the Legendre's differential equation $(1 - x^2)\frac{d^2y}{dx^2} - 2x\frac{dy}{dx} + n(n+1)y = 0$

13. Prove the Rodrigue's Formula $P_n(x) = \frac{1}{2^n n!}\frac{d^n}{dx^n}\left[(x^2 - 1)^n\right]$

14. Express the following polynomials in terms of Legendre polynomials

a) $f(x) = 5x^3 + x$

b) $f(x) = 4x^3 - 2x^2 - 3x + 8$

c) $f(x) = 2x^3 - x^2 - 3x + 2$

d) $f(x) = x^4 + 3x^3 - x^2 + 5x - 2$

e) $f(x) = x^3 + 2x^2 - 4x + 5$

f) $f(x) = x^3 - 5x^2 + 6x + 1$

g) $f(x) = x^3 + 2x^2 - x + 3$

h) $f(x) = x^4 + x^3 + 2x^2 - x - 3$

Module : 3	Title : Complex variables	Planned Hours: 12

Learning Objectives: At the end of this chapter student should be able to

1. **Identify** the analytic functions
2. **Apply** the C-R equations to show the complex functions are analytic.
3. **Recall** the properties of analytic functions.
4. **Construct** the analytic functions given real or imaginary part using Milne Thompson method
5. **Evaluate** Complex Line Integrals by using Cauchy's theorem and formula

6. **Study** of Residue, Poles, Cauchy' Residue Theorem
7. **Interpret** the conformal mapping from z-plane to w-plane under some standard transformation
8. **Find** the Bilinear transformation and the corresponding invariant points

Lesson plan:

Lecture no.	Topics covered	Teaching Method	PSOs	POs attained	COs attained	Ref Book/ Chapter No.
L21	Introduction to function of a complex variable.Limit,continuity,differentiability and analytic function	Chalk and Board	1	1, 2, 4, 5, 11	3	T1/20 T2/13 ,14,16 ,17
L22	Cauchy-Riemann equations in Cartesian form and polar form					
L23	Properties of analytic functions and construction of analytic function f(z) given its real or imaginary parts					
L24	Line integral of Complex valued functions, Examples					
L25	Cauchy's theorem and related examples.					
L26	Cauchy's integral formula and Generalized Cauchy's integral formula -examples					
L27	Residues, Poles, Cauchy's Residue theorem with proof and problem					
L28	Problems.					
L29	Discuss the conformal transformation $w = z^2$, $w = e^z$ - examples					
L30	Discuss the transformation $w = z + \frac{1}{z}$ Examples					
L31	Bilinear transformations					
L32	Problems					

Assignment questions:

Assignment questions	COs Attained
1. Derive Cauchy – Riemann equations in Cartesian form and Polar form.	

2. Define harmonic function. Prove that real and imaginary parts of an analytic function are harmonic in Cartesian and polar form
3. Show that the following functions are harmonic and find their harmonic conjugate. Also find the corresponding analytic function

a) $u = e^{2x}(xcosy - ysin2y)$ b) $u = \frac{2\,cosxcoshy}{cos2x+cosh2y}$

c) $v = \left(r - \frac{1}{r}\right)sin\theta$ d) $v = \frac{-sin\theta}{r}$

e) $v = e^{-x}(xcosy + ysiny)$ f) $u = \frac{1}{r}cos\theta$

g) $v = -sinxsinhy$ h) $u = e^{x}\cos y + xy$

i) $v = e^{-2y}sinx$ j) $u = (x-1)^3 - 3xy^2 + 3y^2$

3

4.Construct analytic function $f(z) = u + iv$ as a function of z using the following data

a) $u - v = e^{x}(cosy - siny)$ b) $u - v = \frac{cosx+sinx-e^{-y}}{2cosx-e^{y}-e^{-y}}$ when $f\left(\frac{\pi}{2}\right) = 0$

c) $u - v = (x-y)(x^2 + 4xy + y^2)$ d) $u + v = \frac{2sin2x}{e^{2y}-e^{-2y}-2cos2x}$

e) $u + v = \frac{1}{r^2}(cos2\theta - sin2\theta)$

5.If $f(z) = u + iv$ is an analytic function of z, then prove that

a) $\left[\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}\right]|f(z)|^2 = 4\left|f'(z)\right|^2$ b) $\left\{\frac{\partial}{\partial x}|f(z)|\right\}^2 + \left\{\frac{\partial}{\partial y}|f(z)|\right\}^2 = \left|f'(z)\right|^2$

c) $\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2 = \left[\left(\frac{\partial f}{\partial u}\right)^2 + \left(\frac{\partial f}{\partial v}\right)^2\right]\left|f'(z)\right|^2$.

3

6. Show that $v = cosxsinhy$ is harmonic and find its harmonic conjugate.

7. Find the harmonic conjugate of $v = log\sqrt{x+y}$ and find its analytic function.

8. Evaluate $\int_C z$ dz where c is the i)straight line from i to i. ii)right half of the unit circle |z| = 1

9. Evaluate $\int_{1-i}^{2+3i}(z^2+z)dz$ along the line joining the points (1, -1) & (2,3)

10. Prove that $\int_C \frac{dz}{z-a} = 2\pi i$, where C is the circle: |z – a |= r.

11.Prove that $\int_C (z-a)^n dz = 0$, (n, any integer ≠ -1),

where C is the circle : |z – a |= r.

12. Evaluate $\int_{1-i}^{2+i}(2x+iy+1)dz$ along the two paths

a) $x = t + 1,\ y = 2t^2 - 1$ b) the straight line joining (1 - i) & (2 + i)

13. Verify Cauchy's theorem for $f(z) = z^2$ taken over the boundary of a square with vertices at ± 1, ± i in counter clockwise direction.

14. Verify Cauchy's theorem for the function $f(z) = 3z^2 + iz - 4$, where c is the Square having vertices 1± i,-1± i.

15. Verify Cauchy's theorem for the function $f(z) = ze^{-z}$ over the unit circle with Origin as the centre.

16. Verify Cauchy's theorem for the integral of z^3 taken over the boundary of the Rectangle with vertices -1, 1, 1 + i , -1 + i .

17. Evaluate $\int_C \frac{e^{2z}}{z-2}dz$ where C is the circle C: |z |= 1.

18. Evaluate $\int_C \frac{z^2+1}{z-3}dz$ where C is the circle C : |z -1 |= 1

19. Verify Cauchy's theorem for the function f(z) = 2 sin 5z , where c is the Square with vertices 1± i,-1± i.

20. Evaluate $\int_C \frac{z^2-z+1}{z-1}\,dz$ where C is the circle a) C : |z |= 1 b) C : |z |= $\frac{1}{2}$

21. Evaluate $\int_C \frac{e^z}{z(1-z)^3}$ where C is

a) C : |z |= $\frac{1}{2}$ b) C : |z -1| = $\frac{1}{2}$ c) C : |z |= 2

22. Evaluate $\int_C \frac{dz}{z^2-4}$ over a) C : |z |= 1 b) C: |z |= 3 c) C: |z + 2 |= 1

23. Evaluate $\int_C \frac{e^z}{z-i\pi}dz$ where C is the circle a) C : |z |= 2π b) C : |z |= $\pi/2$

24.Evaluate $\int_C \frac{e^{2z}}{(z-1)(z-2)}dz$ where C is the circle |z |= 3

25. Evaluate $\int_C \frac{\sin\pi z^2+\cos\pi z^2}{(z-1)^2(z-2)}dz$ where C is the circle |z |= 3.

26.If $f(z)$ has a simple pole at $z = a$,then $Res\, f(a) = \lim_{z\to a}[(z-a)\, f(z)]$

27.Find the sum of the residues of

$f(z) = \frac{\sin z}{z\cos z}$ *at its poles inside the circle* $|z| = 2$

28.Determine the poles of the function $f(z) = z^2/(z-1)^2(z+2)$

And the residue at each pole. Hence evaluate
$\oint f(z)dz$, *where C is the circle* $|z| = 2.5$

29.Evaluate $\oint \frac{z-3}{z^2+2z+5}dz$ where C is the circle

i) $|z| = 1$ ii) $|z + 1 - i| = 2$ iii) $|z + 1 + i| = 2$

30.Evaluate $\oint \frac{\sin\pi z^2 + \cos\pi z^2}{(z-1)^2(z-2)}\, dz$ where C is the circle $|z| = 3$

31. Find the transformation of the straight lines parallel to the axes under the Transformation $w = z^2$.

32.Show that the transformation $w = z^2$ transforms

a) The circle $|z| = a$ to a circle $|w| = a^2$

b) The first quadrant in the z-plane to the upper half of the w-plane

c) The upper half of the z-plane to the entire w-plane.

33. Under the transformation $w = z^2$, find

a) The image of the square region bounded by the lines x = 1,x = 2, y = 1 ,

y = 2.

b) The image of the triangular region bounded by the lines x = 1, y = 1 ,

x + y = 1.

c) The image of the region bounded by ½ ≤ x ≤ 1 and ½ ≤ y ≤ 1.

34. Show that the transformation $w = e^z$ transforms lines parallel to the

a) y axis into concentric circles centered at the origin in the w- plane.

b) x axis into radial lines in the w-plane .

35.Show that under the transformation $w = e^z$

a) y axis is mapped onto the unit circle at the origin in the w-plane.

b) x axis is mapped onto the positive u-axis in the w-plane .

36. Find & draw the image of the rectangular region $-1 \le x \le 3$, $-\pi \le y \le \pi$ in the z-plane

under the transformation $w = e^z$

37.Find the images of the circles lzl = 1 and lzl = 2 under the conformal transformation

$w = z + \frac{1}{z}$ and sketch the region.

38.Discuss the transformation $w = e^z$ and show that it transforms the region

between

the real axis and the line parallel to the real axis at $y = \pi$, into the upper half the

w- Plane.

39. Define bilinear transformation. Find the Bilinear transformation which maps the given

points and the corresponding invariant points.

a) z = 1, i, -1 into w = i, 0, -i

b) z = -1,0,1 into w = 0, i, 3i

c) z = 1, i, -1 into w = 0, 1, ∞

d) z = 0,-i ,2i into w = 5i, ∞, -i/3

e) z = 0,-1, ∞ into w = -1,-2-i , i

f) z = 2,1,0 into w = 1, 0, i,

g) z = -1,i,1 into w = 1, i, -1

h) z = 1, i, -1 into w = 2,i,-2

i) z = i,1, -1 into w = 1, 0, ∞,

j) z = 0, i, ∞ into w = 1, -i, -1

Module - 4	Title **Probability Distributions**	**Planned Hours: 09**

Learning Objectives: At the end of this chapter student should be able to

1.	**Identify** Random variables, Discrete and continuous probability distributions.
2.	**Apply** the concept based on pdf & cdf and evaluate various problems based on it.
3.	**Interpret** mean, variance in Binomial, Poisson, Normal distributions, classify and evaluate and make certain judgments.

Lesson Plan:

Lecture no.	Topics covered	Teaching Method	PSOs	POs attained	COs attained	Ref Book/ Chapter no.
L33	Random variables, Discrete and continuous probability mass/density functions	Chalk and Board	1	1, 2, 4, 5, 11	4	T1/26, T2/22
L34	Examples on Probability functions.					
L35	Binomial distributions, mean and variance and examples					
L36	Poisson distributions, mean and variance and examples					
L37	Exponential distributions, mean and variance and examples					
L38	Normal distributions, mean and variance and examples					
L39	Joint probability distribution for two discrete random variables, examples.					
L40	Expectation, covariance, correlation coefficient.					
L41	Examples					

Assignment questions:

Assignment questions	COs Attained
1. A random variable ‘x’ has the following function values of ‘x’ x: 0 1 2 3 4 5 6 7 y: 0 k 2k 2k 3k k $2k^2$ $7k^2+7$ a) Find k b) Evaluate P(x < 6) c) Evaluate P(x ≥ 6) d) P (3< x ≤ 6)	
2. A coin is tossed twice. A random variable X represents the number of heads turning up. Find the discrete probability distribution for X. Also find its mean and variance.	4
3. Find the value of ‘k’ such that the following represents a finite probability distribution. Hence find its mean and standard deviation. x: -3 -2 -1 0 1 2 3 y: k 2k 3k 4k 3k 2k k	
4. Prove that the mean & S. D of the Binomial distribution are np & $\sqrt{npq}$ respectively	
5. Prove that the mean & S.D of the Poisson distribution are m & $\sqrt{m}$ respectively.	
6. Six coins are tossed. Find the probability of getting a) Exactly 3 heads b) At least 3 heads c) At least one head	
7. A travel agency has 2 cars which it hires daily. The number of demands for a car on each day is distributed as a Poisson variate with mean 1.5. Find the probability that on a particular day a) there was no demand b) a demand is refused.	
8. In a consignment of electric lamps 5% are defective. If a random sample of 8 lamps is inspected, what is the probability that one or more lamps are defective?	
9. The probability of a shooter hitting a target is1/3. How many times he should shoot so that the probability of hitting the target at least once is more than ¾.	
10. Show that mean & standard deviation of exponential distribution are equal.	
11. Find the mean & standard deviation of normal distribution.	
12. The length of telephone conversation has been an exponential distribution & found on an average to be 5 minutes. Find the probability that a random call	

MODULE:5	Title: SAMPLING THEORY & STOCHASTIC PROCESS	Planned Hours: 09

Learning Objectives: At the end of this chapter student should be able to

1. **Outline** the process of sampling made in daily life.
2. **Distinguish** between standard error, null and alternate hypothesis and Type I,II errors.
3. **Classify** and calculate the above said errors and apply known procedure to solve problems.
4. **Interpret** level of significance for means.
5. **Interpret** and explain confidence limits for means of large and small samples.
6. **Apply** known technique and solve the examples.
7. **Interpret** and evaluate scientific hypotheses
8. **Outline** the random process that undergoes transitions from one state to another on a state space.

Lesson Plan:

Lecture no.	Topics covered	Teaching Method	PSOs	POs attained	COs attained	Ref Book/ Chapter no.
L42	Introduction to sampling and sampling distribution and simple examples	Chalk and Board	1	1, 2, 4, 5, 11	5	T1/27, T2/23
L43	Standard error, test of hypothesis for mean and proportions and examples					
L44	Confidence limits for means of large and small samples.					
L45	Student's t-distribution with examples.					
L46	Chi-square distribution as test of goodness of fit.					
L47	Introduction to Stochastic process.					
L48	Probability vector, stochastic matrices.					
L49	Fixed points, regular stochastic matrices.					
L50	Markov chains, higher transition probability.					

Assignment Questions :

Assignment Questions	COs Attained
1. Explain the following terms a) Null hypothesis b) Confidence limits c) Type I& Type II errors d) students''t' distribution. e) level of significance. 2. 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 indicate that the die is unbiased. 3. A random sample of 400 items chosen from an infinite population is found to have a mean of 82 and a standard deviation of 18. Find the 95% confidence limits for the mean of the population from which the sample is drawn. 4. In a city 'A' 20 % of a random sample of 900 school boys had a certain Slight Physical defect. In another city 'B' 18.5% of a random sample of 1600 school boys had the same defect. Is the difference between the proportions significant? 4. One type of aircraft is found to develop engine trouble in 5 flights out of total of 100 & another type in 7 flights out of a total 200 flights. Is there a significant difference in the two types of aircrafts so for as engine defects are concerned? 6. A survey was conducted in a slum locality of 2000 families by selecting a sample of size 800. It was revealed that 180 families were illiterates. Find the probable limits of the illiterate families in the population of 2000. 7. In an examination given to students at a large number of different schools the mean grade was 74.5 & S.D grade was 8. At one particular school where 200 students took the examination the mean grade 75.9. Discuss the significance of this result from the view point of a) one tailed test b) two tailed test at both 5 % & 1% level of significance. 8. Random sample of 1000 engineering students from a city A and 800 from city B were taken. It was found that 400 students in each of the sample were from payment quota. Does the data reveal the significant difference between the two cities in respect of payment quota students. 9. A sample of 400 items is taken from a normal population whose mean is 4 & variance 4. If the sample mean is 4.45, Can the samples be regarded as a simple 10. The mean of two large samples of 1000 & 2000 members are 168.75 cms and 170 cms respectively. Can the samples be regarded as drawn from the same population of standard deviation of 6.25 cms 11. Balls are drawn from a bag containing equal number of black & white balls , each ball being replaced before drawing another . In 2250 drawings 1018 black & 1232 white balls have been drawn. Do you suspect some bias on the part of the drawer? 12. A coin is tossed 400 times and it turns up head 216 times. Discuss whether the coin may be an unbiased one at 5% level of significance. 13. It is required to test whether the proportion of smokers among students is less than that among the lectures. Among 60 randomly picked students, 2 were smokers. Among 17 randomly picked lectures, 5 were smokers. What would be your conclusion? 14. From a random sample of 10 pigs fed on diet A, The increase in weight in the certain period were 10, 6,16,17,13,12,8,14,15,9 lbs. For another sample of 12 pig fed on diet B, the increase in the same period were 7,13,22,15,12,14,18,8,21,23,10,17 lbs. Test whether diets A & B differ	**5** **5**

8. Portion for I.A. Test:

I. A. Test No.	Modules
I	I and II or I and IV
II	III and IV or II and IV

9. List of Program Outcomes:

1. An ability to apply knowledge of mathematics, science, and engineering.
2. An ability to design and conduct experiments, as well as to analyze and interpret data.
3. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
4. An ability to function on multidisciplinary teams.
5. An ability to identify, formulate, and solve engineering problems.
6. An understanding of professional and ethical responsibility
7. An ability to communicate effectively (Oral)
8. An ability to communicate effectively (Written)
9. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context.
10. A recognition of the need for, and an ability to engage in life-long learning.
11. A knowledge of contemporary issues.

Course Title: Kinematics of Machines (15ME42)

Program Educational Objectives (PEOs)

The educational objectives of the Mechanical Engineering Program are to prepare our graduates to:

1. Establish a successful career in Mechanical Engineering or related fields in Industry and other organizations where an engineering approach to problem solving is highly valued.
2. Develop the ability among the students to synthesize the data and technical concepts for applications to the product design.
3. Contribute significantly in a multidisciplinary work environment with high ethical standards and with understanding of the role of engineering in economy and the environment.
4. Excel in graduate study and research, reaching advanced degrees in engineering and related disciplines.
5. Achieve success in professional development through life-long learning.

Program outcomes (POs)

a. an ability to apply knowledge of mathematics, science, and Mechanical Engineering
b. an ability to design and conduct experiments, as well as to analyze and interpret data
c. an ability to design a mechanical system, mechanical component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d. an ability to function on multidisciplinary teams
e. an ability to identify, formulate, and solve mechanical engineering problems
f. an understanding of professional and ethical responsibility
g. an ability to communicate effectively
h. the broad education necessary to understand the impact of mechanical engineering solutions in a global, economic, environmental, and societal context
i. a recognition of the need for, and an ability to engage in life-long learning,
j. a knowledge of contemporary issues
k. an ability to use the techniques, skills, and modern mechanical engineering tools necessary for engineering practice.

Department of: Mechanical													
Program: Mechanical Engineering													
Course Title: Kinematics of Machines Course Code:15ME42 Theory: x Practical:													
Prerequisites to this course: (Course title with course codes)			Maths(15 ME11)		MOM(15 ME34)		EME(15M E14/24)						
Program Outcomes (POs)	a	b	c	d	E	f	g	h	i	j	k	l	m
	x		x		X			x	x				
Mapping of Course Outcomes with POs	1,2,3		1,2,3		1,2,3			1,2,3	1,2,3				

Course category	Basic Sciences	General Humanities General/	Core						Elective
			G-A	G-B	G-C	G-D	G-E	G-F	
				X					

Teaching Methods:	PPT	OHP	Face to face	Guest Lecture	Video lecture	Demo (Lab visit)	Seminars	Industrial visits
Module	I.V		II,III,IV		I, V			

Continuous Assessment	Internal assessment tests	Assignment	Tutorial
	03	03	08

Contents beyond syllabus to meet POs:	Topics	POs attained
	1. 2. 3.	

Approved by:	Module Coordinator	Prof S S Chappar
	Program coordinator	Prof S.B.Koulagi

Achieving Intended Course Learning Outcomes

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

Sl.No.	Course Learning Outcomes	Possible capabilities, skills, expertise gained (codes)	Means of imparting the curriculum
1	CO1	Kn	Class room lectures
2	CO2	Un	Class room lectures
3	CO3	PSS, AS	Assignments, Tutorials
4	CO2	PS	Class room lectures
5	CO2	AK, PS	Lab visit
6	CO3	SS	Mini project

Possible capabilities, skills, expertise gained	**Code**
Knowledge	Kn
Understanding (Comprehension)	Un
Problem solving skills (application skills)	PSS
Practical skills (application skills)	PS
Analytical skills	AS
Synthesis skills	SS
Written communication skills	WCS
Verbal/oral communication skills	VCS
Presentation skills	PS
Leadership skills	LS

Course Plan

Semester: IV **Year: 2017-18**

Course Title	Kinematics of Machines	Course Code	15ME42
Total Teaching Hours	50	Teaching hours/week	04
Internal Assessment Marks	20	Semester Exam Marks	80
Course Plan prepared by	Prof P.S Kori Prof S.S Kulkarni Prof A.T Patil	Date:	23-01-2017

Course Content

Module 1	
Introduction: Definitions: Link, kinematic pairs, kinematic chain, mechanism, structure, degrees of freedom, Classification links, Classifiction of pairs based on type of relative motion, Grubler's criterion, mobility of mechanism, Groshoff's criteria, inversions of Grashoff's chain. **Mechanisms:** Quick return motion mechanisms-Drag link mechanism, Whitworth mechanism and Crank and slotted lever Mechanism. Oldham's coupling, 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 Coriolis 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. **Klein's Construction:** Analysis of velocity and acceleration of single slider crank mechanism.	10 Hours
Module 3	
Velocity and Acceleration Analysis of Mechanisms (Analytical Method): Velocity and	10 Hours

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	
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, back lash, condition for minimum number of teeth to avoid interference, expressions for arc of contact and path of contact . **Gear Trains:** Simple gear trains, compound gear trains. Epicyclic gear trains: Algebraic and tabular methods of finding velocity ratio of epicyclical gear trains, torque calculation in epicyclical gear trains.	10Hours
Module 5	
Cams: Types of cams, types of followers. displacement, velocity and acceleration curves for uniform velocity, Simple Harmonic Motion, Uniform Acceleration Retardation, Cycloidal motion. Cam profiles: disc cam with reciprocating / oscillating follower having knife-edge, roller and flat-face follower inline and offset. Analysis of **Cams:** Analysis of arc cam with flat faced follower.	10Hours

Graphical Solutions may be obtained either on the Graph Sheets or in the Answer Book itself.

TEXT BOOKS:

T1. Rattan S.S, Theory of Machines, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 4th Edition, 2014.

T2 . Ambekar A. G., Mechanism and Machine Theory, PHI, 2009.

REFERENCE BOOKS:

R1. Michael M Stanisic, Mechanisms and Machines-Kinematics, Dynamics and Synthesis, Cengage Learning, 2016.

R2. Sadhu Singh, Theory of Machines, Pearson Education (Singapore)Pvt. Ltd, Indian Branch New Delhi, 2nd Edi. 2006.

Scheme of Examination:

Two questions will be set from each module. Students have to answer FIVE questions selecting at least one from each module

Assessment	Marks

Internal Assessment tests	20
VTU Semester examination	80
Total	**100**

COURSE DESCRIPTION:

1. Overview of the Course:

Kinematics of Machine or Theory of machine-I includes such subjects as Kinematics, statics, Kinetics, mechanisms, Kinematic chain and inversions. Velocity and acceleration analysis of different mechanisms, Transmission system and cam follower. This subject intended to cover the field of theory, analysis, design and practice that is generally described as mechanisms, Kinematics and Dynamics of machines.

2. Relevance of the course:

This course is necessary for mechanical engineering students as basics in dynamics of machinery design of machine elements I & II, Mechanics, Robotics and Automation. Also, course provides background for mechanism design, Engineering design, fatigue life, mode of failure and other aspects important to the proper design of mechanical systems.

3. Applications areas:

Machine tool industry, textile machines, automotive material handling, medical appliances like dentist chair, OT tables, arms and ammunitions, agricultural and home appliances requires the basics of this subject.

4. Prerequisites:

This subject requires basics of engineering mathematics, engineering drawing and engineering physics, Mechanics, Elements of mechanical engineering.

Course objectives

Students will

1. Familiarize with mechanisms and motion analysis of mechanisms.
2. Understand methods of mechanism motion analysis and their characteristics.
3. Analyze motion of planar mechanisms, gears, gear trains and cams.

Course outcomes

Students will be able to

1. Identify mechanisms with basic understanding of motion.
2. Comprehend motion analysis of planar mechanisms, gears, gear trains and cams.
3. Carry out motion analysis of planar mechanisms, gears, gear trains and cam

Internal Assessment Portion

IA	Syllabus
I	Module I and II
II	Module IV and V
III	Module III

Module wise lesson plan

Course title and code: **Kinematics of Machines (15ME42)**	
Module 1	Planned Hours: **10**

Learning Objectives:

At the end of this chapter student will be able to,

- Define link or element, Machine, mechanism, structure, kinematic pair. Kinematic chain.
- Compute the degree of freedom of various mechanisms.
- Explain mobility of mechanism and inversion.
- Explain the working of Quick return mechanisms- Drag link mechanisms, Whitworth mechanism and Crank and slotted lever mechanism.
- Demonstrate the Straight line motion mechanisms- Peaucellier's mechanism, Robert's mechanism.
- Explain the working of intermittent motion mechanisms- Geneva mechanism, Ratchet and Pawl mechanism etc

Lesson Schedule:

Lecture No	Topics Covered	Teaching Method	Po's Attained	Co's Attained	Reference Book/Chapter No
L1	INTRODUCTION- Definitions; link or element, kinematic pair.	Chalk & Board	a, e, h ,i	1	T1,T2 ,R1
L2	Definitions; link or element, kinematic pair, Kinematic chain, mechanism, structure, mobility of mechanism,	PPT	a, e, h ,i	1	T1,T2 ,R1
L3	Degrees of freedom, Grubler's criterion (without derivation), Groshoff's Criteria and inversions	Chalk & Board	a, e, h ,i	1	T1,T2,R1
L4	KINEMATIC CHAIN AND INVERSIONS**:** Inversions of four bar chain,	PPT/Chalk & Board	a, e, h ,i	1	T1,T2,R1
L5	Inversions single slider crank chain,	Chalk & Board PPT	a, e, h ,i	1	T1,T2 ,R1

	Inversions double slider crank chain				
L6	**MECHANISMS:** Quick return mechanisms-Drag link mechanisms, Whitworth mechanism and Crank and slotted lever mechanism.	Chalk & Board	a, e, h ,i	1	T1,T2 ,R1,R2
L7	Straight line motion mechanisms- Peaucellier's mechanism, Robert's mechanism,	PPT/Chalk & Board	a, e, h ,i	1	T1,T2,R1,R2
L8	Intermittent motion mechanisms- Genava mechanism and Ratchet and Pawl mechanism.	PPT/Chalk & Board	a, e, h ,i	1	T1,T2,R1,R2
L9	Toggle mechanisms, Pantograph mechanism,	PPT/Chalk & Board	a, e, h ,i	1	T1,T2,R1,R2
L10	Ackerman steering mechanism.	Chalk & Board	a, e, h ,i	1	T1,T2,R1,R2

Assignment Questions

Q.No	Assignment questions	COs attained
1	Explain the term kinematic link. Give the classification of kinematics of link.	**1**
2	Classify and explain different types of Kinematic pairs with examples.	**1**
3	Distinguish between Plane motion, helical motion and Spherical motion.	**1**
4	Explain the method used to find out whether chain is kinematic chain or not.	**1**
5	Explain the difference between the lower Kinematic pair and higher Kinematic pair and give two examples each.	**1**
6	What is an inversion? With neat sketches explain inversions of double slider	**1**

	mechanism.	
7	Sketch and explain any two inversions of double slider crank chain.	**1**
8	Define the following terms: i) Kinematic link ii) Kinematic pair. iii) Inversion iv) Mechanism v) Machine	**1**
9	With a neat sketch explain all the inversions of single slider crank chain.	**1**
10	Explain the inversions of double slider crank chain with neat sketches.	**1**
11	Differentiate between a) Machine and mechanism b) Kinematic chain and structure c)Lower pair and Higher pair d) Mobility & Degree of Freedom. What is an inversion? Explain any three inversions of a four bar chain	**1**
12	Define the terms and explain the difference between Mechanism and Machine.	**1**
13	Prove the condition to be satisfied to get exact straight-line motion for pantograph.	**1**
14	Give neat sketch of the straight-line motion "Hart Mechanism". Prove that it produces an exact straight line.	**1**
15	What are straight-line mechanisms? Describe one type of exact straight-line motion mechanism with the help of sketch.	**1**
16	Explain the following mechanism with neat sketches and state on which kinematic chain is based a) Elliptical trammel b) Whitworth quick return mechanism.	**1**
17	Explain Grubler's criterion for determining degree of freedom for mechanism.	**1**
18	Obtain the correct condition for correct steering for a four wheeled vehicle.	**1**
19	Derive the condition for a mechanism to trace an exact straight line path	**1**
20	Prove that the Peaucellier's mechanism can be used to draw exact straight line motion.	**1**
21	What is pantograph with aid of a neat sketch of pantograph explain its working principle.	**1**
22	In a crank & slotted lever quick return motion mechanism the distance between the fixed centers 'O' & 'C' is 200 mm. The driving crank CP is 75 mm long. The pin Q on the slotted lever 360 mm from the fulcrum 'O' is connected by a link QR 100 mm long to a pin R on the ram. The line of stroke of R is perpendicular to OC & intersects OC produced at a point 150 mm from C. Determine the ratio of time taken on the cutting & return stroke.	**1**
23	Explain Graoshoff's Criteria and its inversions	**1**

Module wise lesson plan

Course title and code : **Kinematics of Machines (15ME42)**	
Module 2	Planned Hours: **10**

Learning Objectives:

At the end of this chapter students will be able to,

- Evaluate the velocity and acceleration by vector polygons of four bar mechanism, slider crank chain mechanism and simple mechanisms
- Explain the relative velocity and acceleration of particles on a common link.
- Explain and determine the velocity and acceleration of coincident particles on separate links. Explain and determine Coriolis component of acceleration.
- Evaluate the angular velocity angular acceleration of links, velocity of rubbing.
- Explain the Kennedy's theorem.
- Evaluate linear and angular velocity using instantaneous center method.
- Demonstrate the velocity and acceleration diagrams of single crank mechanism using Klein's construction method.

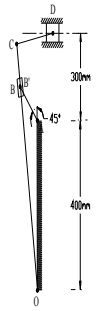
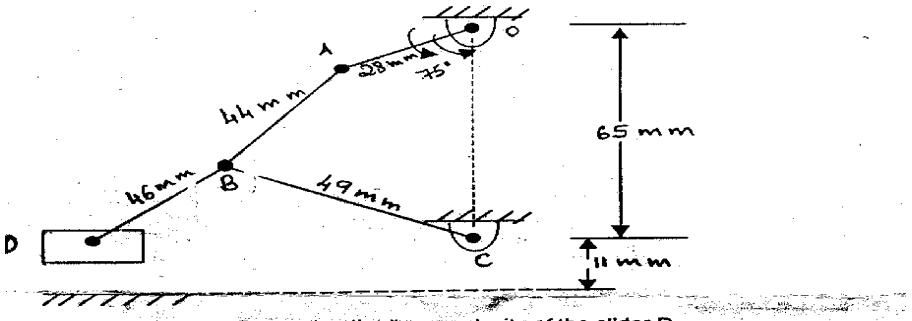
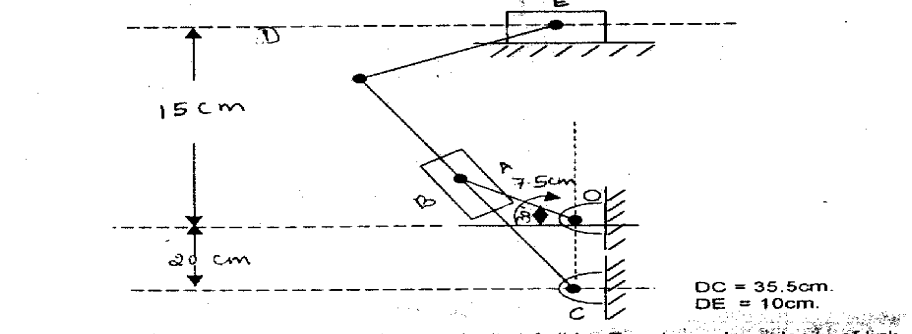
Lesson Schedule:

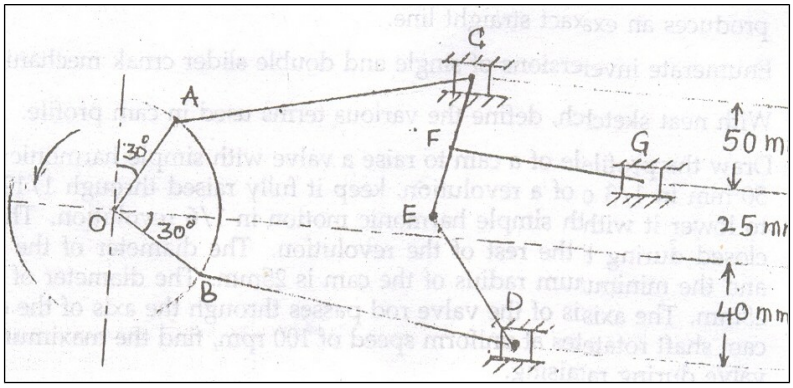
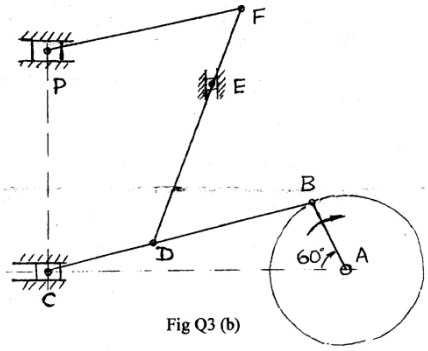
Lecture No	Topics Covered	Teaching Method	Po's Attained	Co's Attained	Reference Book/Chapter No
L11	Velocity and acceleration analysis of four bar mechanism by vector polygons,	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1
L12	Slider crank chain mechanism and simple mechanisms by vector polygons: relative velocity and acceleration of particles on a common link, Velocity and Acceleration of	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1

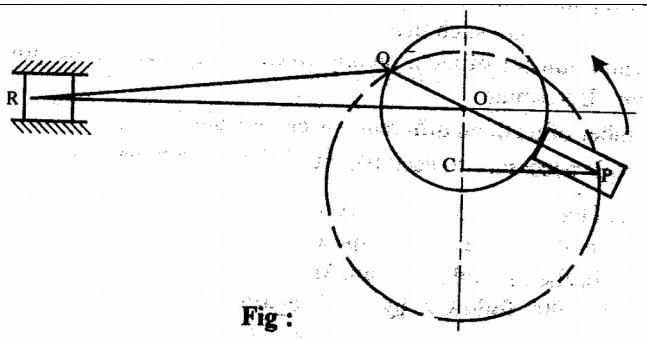
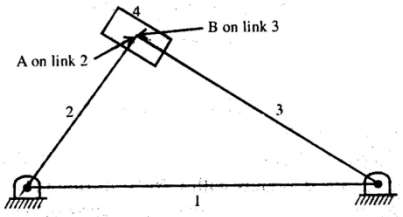
	coincident particles on separate links.Problems				
L13	Coriolis component of acceleration,Problems	Chalk & Board	a, e, h ,i	2,3	T1,T2,R1
L14	Angular velocity angular acceleration of links, velocity of rubbing,Problems	Chalk & Board	a, e, h ,i	2,3	T1,T2,R1
L15	Definition, Kennedy's theorem, determination of linear and angular velocity using instantaneous center method.	Chalk & Board	a, e, h ,i	2,3	T1,T2,R1
L16	Problems	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1
L17	KLEIN'S CONSTRUCTION: Analysis of velocity and acceleration of single crank mechanism	Chalk & Board	a, e, h ,i	2,3	T1,T2,R1
L18	Problems	Chalk & Board	a, e, h ,i	2,3	T1,T2,R1
L19	Problems	Chalk & Board	a, e, h ,i	2,3	T1,T2,R1
L20	Problems	Chalk & Board	a, e, h ,i	2,3	T1,T2,R1

Assignment Questions:

Q.No	Assignment questions	COs attained
1	Write a note on coriolis component of acceleration.	2,3
2	A four bar chain ABCD has a fixed link AD=1m. The driving crank AB=0.3m. The follower link CD=0.6m and the connecting link BC=1.2m. Find the velocity and acceleration of point P, midway between B&C, when the angle BAD=135º and AB rotates clockwise at a speed of 300rpm,with an angular acceleration of 20 rad/sec^2 in CCW direction.	2,3
3	A crank and slotted lever quick return motion mechanism is shown in the fig.(1). If the crank rotates counter clockwise at 120 rpm, determine for the configuration	2,3

	shown, the velocity and acceleration of the ram D. also determine angular acceleration of the slotted lever. Crank , AB=150 mm, Slotted arm, OC=700mm and link, CD=200mm  Fig.1	
	OA rotates at 600rpm. Determine the linear velocity of the slider D.  OA rotates at 200rpm. Determine the linear velocity of slider E and angular velocity of link DE  	
4	Draw the acceleration diagram of slides crank mechanism. In the mechanism as shown OA and OB are two equal cranks at right angles rotating about at a speed of 40 rpm anticlockwise. The dimensions of the various links are as follows.OA =OB = 50 mm , AC = BD = 175 mm, DE = CE = 75 mm,FG = 115 mm and EF = FC Draw velocity diagram for the given configuration of the mechanism and find velocity of the slider G.	2,3

		
5	In a crank and slotted lever quick return motion mechanism the distance between the fixed centers 'O' and 'C' is 200 mm. the driving crank CP is 75 mm long. The pin Q on the slotted lever 360 mm from the fulcrum 'O' is connected by a link QR 100 mm long to a pin R on the ram. The line of stroke of R is perpendicular to OC and intersects OC produced at a point 150 mm from C, determine the ratio of time taken on the cutting and return strokes.	2,3
6	In the mechanism shown in figure Q3 (b) the crank AB rotates at 200 rpm. Find the velocities of C, D, E, F and P. Also find the acceleration of the slider at C. The dimensions of the various links are AB =12 cm, BC=48 cm, CD=18 cm, DE=36 cm, EF=12 cm and FP=36cm.  Fig Q3 (b)	2,3
7	The Whitworth Quick return motion mechanism is shown in the figure. the distance between fixed centers O & C is 40mm, the driving link CP is 125 mm long, the slotted link OQ is 100 mm long & connecting link QR is 375 mm long. The pin R is attached to the ram which carries a tool box and reciprocates along a line passing through O and is perpendicular to OC. If CP rotates at 200 rpm, find the velocity & acceleration of R. CP is perpendicular to OC. OC=40mm , OQ=100mm, CP=125mm,QR=375mm.	2,3

	 Fig :	
8	What is Coriolis component? Derive the expression for the same.	2,3
9	A quick return motion mechanism is shown in Fig 3(b). Link 2 rotates uniformly at 20rad/sec in clockwise direction. Determine the angular acceleration of link 3.OC=350mm,CA=150mm,CB=250mm  **Fig. 3 (b)**	2,3
10	State and prove Kennedy's theorem	2,3
11	What is instantaneous center?	2,3
12	Locate all the instantaneous centers for the following	2,3
13	Explain Klein's construction.	2,3
14	In a reciprocating engine length of crank is 250mm and length of connecting rod is 1000mm. The crank rotates at a uniform speed of 300rpm CW. By KLEIN'S construction determine i) Velocity of piston and angular velocity of connecting rod ii) Acceleration of piston & angular acceleration of connecting rod. Crank is at 30º from i.d.c.	2,3
15	The lengths of the crank and connecting rod of a reciprocating engine are 200 mm and 800 mm respectively The crank is rotating at a uniform speed of 480 rpm. Using Klien's construction, find i) Acceleration of the piston ii) The acceleration of the middle point of the connecting rod and iii) Angular acceleration of the connecting rod when the crank has turned through 45 degree from the inner dead centre.	2,3
16	The crank of a reciprocating engine is 60 mm long and the connecting rod is 240 mm long. The crank rotates at 400 rpm. Find the velocity & acceleration of the piston & the angular velocity & angular acceleration of the connecting rod, when	2,3

	the crank is 30 degrees from inner dead centre,by Klein's construction.	
17	In a slider crank mechanism the lengths of crank and connecting rod are 125 mm & 500mm respectively. The centre of gravity G of the connecting rod is 275 mm from the slider. The crank speed is 600 rpm clockwise. The crank makes 45 degrees from IDC Clockwise. For the position locate all instantaneous centers and find velocity of the slider, Point g and angular velocity of the connecting rod. By Klein's construction determine the acceleration of the slider and point G.	2,3

Module wise lesson plan

Course title and code: **Kinematics of Machines (15ME42)**	
Module 4	Planned Hours: **10**

Learning Objectives:

At the end of this chapter students will be able to,

- Explain gear terminology and law of gearing.
- Explain the characteristics of involutes action, path of contact, arc of contact and contact ratio and principle of interference in involutes gears.
- Explain the methods of avoiding interference, backlash.
- Compare involutes and cycloidal teeth profile.
- Explain simple gear trains, compound gear trains for large speed reduction, epicyclical gear trains.
- Explain the algebraic methods of finding velocity ratio of epicyclical gear trains.
- Explain the tabular methods of finding velocity ratio of epicyclical gear trains.
- Evaluate the tooth load and torque calculations in epicyclical gear trains.

Lesson Schedule:

Lecture No	Topics Covered	Teaching Method	Po's Attained	Co's Attained	Reference Book/Chapter No
L21	SPURE GEARS**:** Gear terminology law of	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1,

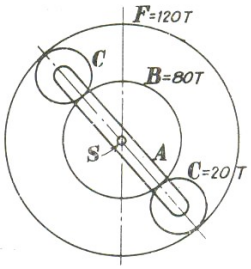
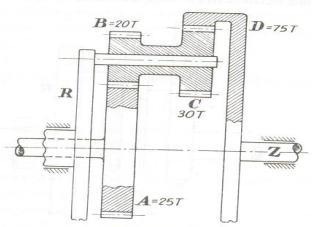
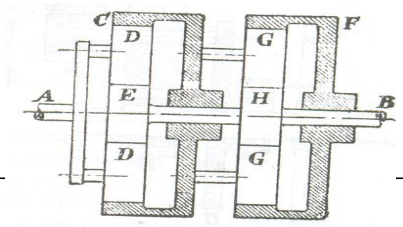
	gearing, characteristics of involutes action, Path of contact,	PPT			
L22	Arc of contact, Contact ratio,Problem	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1,
L23	Interference in involutes gears, methods of avoiding interference,Problems	Chalk & Board	a, e, h ,i	2,3	T1,T2,R1,
L24	Backlash, comparison of involutes and cycloidal teeth.	Chalk & Board PPT	a, e, h ,i	2,3	T1,T2 ,R1,
L25	GEAR TRAINS**:** Simple gear trains , Compound gear trains for large speed reduction,	Chalk & Board PPT	a, e, h ,i	2,3	T1,T2 ,R1,
L26	PROBLEMS	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1,
L27	Epicyclical gear trains, algebraic methods of finding velocity ratio of epicyclical gear trains.	Chalk & Board	a, e, h ,i	2,3	T1,T2,R1,
L28	PROBLEMS	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1,
L29	Epicyclical gear trains tabular methods of finding velocity ratio of epicyclical gear trains. Tooth load and torque calculations in epicyclical gear trains.	Chalk & Board	a, e, h ,i	2,3	T1,T2,R1,
L30	PROBLEMS	Chalk & Board	a, e, h ,i	2,3	T1,T2 R1,

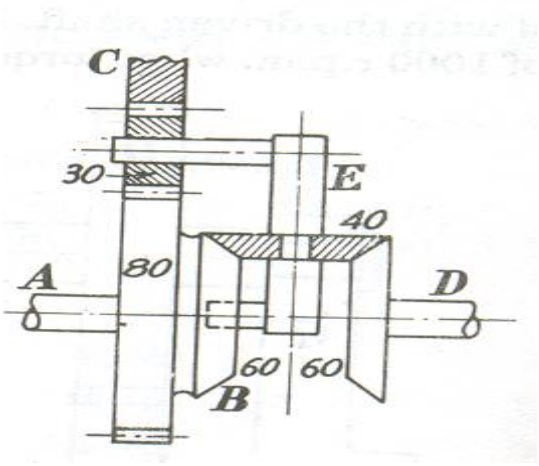
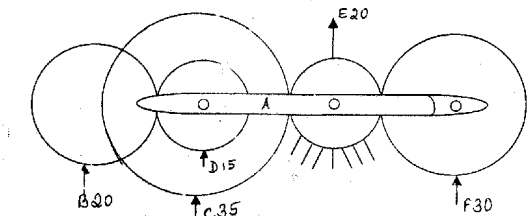
Assignment Questions:

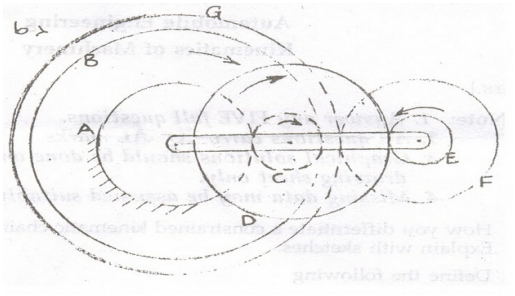
Q.No	Assignment questions	Co's attained

1	State and prove law of gearing.	2,3
2	Derive an expression for length of contact.	2,3
3	Derive an expression for arc of contact.	2,3
4	Derive an expression for path of contact	2,3
5	Give the nomenclature of gear.	2,3
6	What are the forms of gear teeth.	2,3
7	Give the classification of gear trains.	2,3
8	Give the comparison between cycloidal and involute teeth profiles.	2,3
9	Discuss the methods of avoiding interference in gear drives	2,3
10	What is interference? Show that the minimum number of teeth theoretical required on the pinion is a function of tooth form, in order to avoid interference.	2,3
11	Derive an expression for the velocity of sliding between a pair of involutes teeth.	2,3
12	Two spur gears have 24 & 30 teeth and a standard addendum of one module. The pressure angle is 20º. Calculate the path of contact and arc of contact.	2,3
13	For two involute gears in mesh, with pinion as the driver the arc of appro not less than 4.0 times the module. If the pressure angle is 20º and velocity ratio is 2.5 Find i) least number of teeth on each gear if interference is just avoided and ii) Addendum on the gear in terms of module.	2,3
14	A pair of gear has 16 teeth & 18 teeth, a module 12.5mm and addendum 12.5mm and a pressure angle 14.5º. Prove that gears have interference. Determine the minimum number of teeth and velocity ratio to avoid interference.	2,3
15	A pinion having 25 teeth drives a gear having 60 teeth. The tooth profile is in volute with pressure angle of 20^0, module 8 mm and addendum equal to 1module. Determine a) length of the path of contact. b) arc of contact and c) the contact ratio	2,3
16	A pair of 20^0 full depth involute spur gears having 30 and 50 teeth respectively of module 4mm are in mesh and the smaller gear rotates at 1000 rpm. Determine Sliding velocities at engagement and disengagement of pair of a teeth and Contact ratio.	2,3
17	A pair of spur wheels with involute teeth is to give a gear ratio of 3 to 1. The arc of approach is not to be less than the circular pitch and the smaller wheel is the driver. The pressure angle is 20°. What is the least no. of teeth that can be used	2,3

	on each wheel? What is the addendum of the wheel in terms of the circular pitch?	
18 a. b. i. ii. iii. iv. v.	Derive the expression $t_2 = 2r_2 [t_1/2r_1 + inv\phi_1 - inv\phi_2]$ where t_2 --- tooth thickness to be determined t_1---- tooth thickness at pitch circle r_2--- radius at which tooth thickness is to be determined r_1 --- radius of pitch circle ϕ_1--- pressure angle corresponding to r_1 ϕ_2--- pressure angle corresponding r_2	2,3
19	If the involute that is formed at the outline of the gear tooth are extended , they will intersect and tooth becomes pointed. Determine the radius at which this occurs for a tooth which has a thickness of 6.65 mm at a radius of 100 mm and pressure angle 20 degrees	2,3
20	Two equal spur gears of 48 teeth mesh together with pitch radii of 100mm.Andthe addendums are 4.25mm. If the pressure angle is 20º, calculate the length of action and contact ratio.	2,3
21	Two gears in mesh have a module of 8mm & a pressure angle of 20º. The larger gear has 57 teeth while the pinion has 23 teeth. If the addendum on a pinion and gear wheel are equal to 1 module, find i) The number of pairs of teeth in contact ii) the angle of action of the pinion and the gear wheel	2,3
22	Explain with sketches a) Simple GT b) Compound GT c) Reverted GT d) Epicyclical GT	2,3
23	Explain with a neat sketch working of an automobile differential gear.	2,3
24	The following are the particulars of a single reduction spur gear. The gear ratio is 10:1 and center distance is 275mm. the pinion transmits 375kw at 1800rpm. The teeth are of involutes form with standard addendum of one module and pressure angle is 22.5º. The normal tooth pressure not to exceed 9810N/cm. find a. The nearest standard diameter pitch if no interference is to occur b. The number of teeth in each wheel.	2,3
25	In an epicyclic gear train, the internal wheel A and B compound wheel C and D rotate independently about axis O. The wheel E and F rotate on pins fixed to arm G. E gears with A and C and F gears with B and D. All wheels have the same module and number of teeth are T_c=28 TD=26 T_E=T_F=18. a. Sketch the arrangement b. Find the number of teeth on A and B	2,3

	c. If the arm G makes 100 rpm clockwise and A is fixed, find speed of B d. If the arm G makes 100rpm clockwise and wheel A makes 10rpm, CCW. Find speed of B.	
26	An epicyclic gear train is composed of a fixed annular wheel A having 150 teeth. Meshing with A is a wheel B which drives wheel D through an idle wheel C. D having concentric with A. Wheels B & C carried on an arm which revolves clockwise at 100 rpm about the axis of A & D. If wheels A & D have 25 & 40 teeth respectively find the number of teeth on C and the speed And sense of rotation of C.	2,3
27	Fig shows an epicyclic gear in which arm A is fixed to the shaft S, B is free to rotate on S and F is separately driven. A receives 7.5 kW at 200 rpm, and F is driven in the same Direction at 100 rpm. Determine the speed of B and the torque on its shaft. 	2,3
28	An epicyclic gear is shown. The arm R rotates at 1000rpm and gear A is fixed. Determine a)rpm of the shaft Z b) the torque on the fixed gear, if the arm transmits 7.5kW. 	2,3
29	In the epicyclic train shown , the shaft A transmits 7.5 kW to the shaft B. If the shaft A rotates at 700 rpm. Find the torque transmitted by the pinions E and H respectively The wheels G and H have 30 teeth; D & E have 52 teeth Each. Wheel F is fixed 	2,3

34	In the gear shown, the wheel C is fixed and the wheel A rotates at 250 rpm. The bevel wheel B is rigidly fastened to A. Find the speed of shaft D.  	2,3
35	Wheel E is fixed and wheels C & D are integrally cast. If "A" makes 100 revolutions per second counter clockwise. Determine the speed & direction of rotation of wheels B & F.  	2,3
36	Figure shows an epicycle gear train with the following details. A has 40 teeth external (fixed gear) ; B has 80 teeth internal : C-D is a compound wheel having 20 and 50 teeth (external) respectively, E and F is a compound wheel having 20 and 40 teeth (external) respectively and G has 90 teeth (external). The arm runs at 100 rpm in clockwise direction. Determine the speeds for	2,3

	gears C,E and B.  	
37	In an epicyclical gear train of sun and planet type, the pitch circle diameter of the annular wheel A is to be nearly equal 220 mm and the module is 4 mm. when the annular wheel is stationary, the spider which carries three planet gears P of equal size has to make one revolution for the driving spindle carrying sun wheel S. Determine the number of teeth on all the wheels and also the exact diameter of pitch circle of wheel A	2,3
38	In an epicycle gear train, the internal wheel A & B , the compound wheel C & D rotate independently about axis O. The wheel E & F rotate on the pins fixed to the arm G E gears with A and C and F gears with B and D. All wheels have the same module and the number of teeth are T_C=28,T_D=26,T_E=T_F=18 Sketch the arrangement 1. Find the number of teeth on A & B 2. If the arm G makes 100 rpm clockwise and A is fixed, find speed of B 3. If the arm G makes 100 rpm clockwise and wheel A makes 10 rpm counter clockwise find speed of B.	2,3

Module wise lesson plan

Course title and code: **Kinematics of Machines (15ME42)**	
Module 5	Planned Hours: **10**

Learning objectives:

At the end of this chapter students will be able to,

- Explain types of cams, types of follower.
- Explain the displacement, velocity and acceleration time curves for SHM, uniform velocity, uniform acceleration and retardation and cycloidal motion.
- Create the disc cam profiles for reciprocating follower having knife- edge, roller and flat faced follower.
- Identify disc cam profile for oscillating roller follower.

Lesson Schedule:

Lecture No	Topics Covered	Teaching Method	Po's Attained	Co's Attained	Reference Book/Chapter No
L31	Types of cams, types of follower,	Chalk & Board PPT	a, e, h ,i	2,3	T1,T2 .R1
L32	Displacement, velocity and acceleration time curves for cam profiles.	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1
L33	Follower motions including SHM, uniform velocity, uniform acceleration and retardation and cycloidal motion.	Chalk & Board	a, e, h ,i	2,3	T1,T2,R1
L34	Disc cam with reciprocating follower having knife- edge, roller	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1
L35	PROBLEMS	Chalk & Board	a, e, h ,i	2,3	T1,T2,R1
L36	Flat faced follower, disc cam with oscillating roller follower.	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1
L37	PROBLEMS	Chalk & Board	a, e, h ,i	2,3	T1,T2 R1
L38	PROBLEMS	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1
L39	Analysis of arc Cams with flat faced follower	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1
L40	PROBLEMS	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1

Assignment Question:

Question Number	Assignment questions	COs attained
1	Derive an expression for max. velocity and acceleration for uniform acceleration and retardation	2,3
2	Derive an expression for max. velocity and retardation for clycloidal motion.	2,3
3	Draw the profile of a cam operating a knife edge follower having lift of 30mm. The cam raises the follower with uniform velocity for 150º of cam rotation followed by a dwell period of 60º. The follower descends for next 100º of rotation of the cam with uniform velocity, again followed by dwell. The cam rotates at uniform velocity of 120 rpm and has a least radius of 20mm. what will be the maximum velocity and acceleration of the follower during the lift and return? Draw the profile for the same problem60, with lift and r return with SHM. 20.	2,3
4	Draw the profile for the same problem 3, with lift and return with UARM.	2,3
5	Draw the profile for the same problem 3, with lift and return with Cycloidal motion.	2,3
6	Draw the profile for the same problem 3, with lift with SHM and return with UARM.	2,3
7	Draw the profile for the same problem 3, If the follower is offset by 12mm towards right of cam axis.	2,3
8	Draw the profile of a cam operating a roller reciprocating follower and with the follower and with the following data. Minimum radius of cam=25mm, Lift =30mm, Roller diameter =15mm	2,3
9	The cam lifts the follower for 120º with SHM followed by a dwell period of 30º. The follower lowers down during 150º of the cam rotation with UARM followed by a dwell period. If the cam rotates at uniform speed of 150 rpm, calculate the maximum velocity and acceleration of the follower during the descend period.	2,3
10	Draw the profile of a cam for the problem 6, with Offset of follower axis = 10mm towards right.	2,3
11	Draw the full size cam profile for cam with roller of 25 mm diameter attached to the follower to give a lift of 35 mm. The axis of the follower is offset to right of cam axis is 18 mm. Ascent of the follower takes place with SHM 0.05 sec. followed by a period of rest 0.0125 sec. The follower then descent with UARM	2,3

	during 0.125 sec. and the remaining period rest at the minimum lifted position, acceleration being ¾ times retardation. A cam rotates in anticlockwise direction at a constant speed 240 rpm and base radius is 50 mm	
12	A push rod operated by a cam is to rise and fall with SHM along an inclined straight path, the least radius of the cam is 40 mm. The push rod carries a roller 30 mm diameter at its lower end. In the lowest position the roller centre is vertically above the cam axis. Maximum displacement of the follower is 40 mm in a direction 30 degrees to the right of the vertical. The time of the lift is 0.15 sec, the time of the fall is 0.1 sec and the period of the rest at the upper end is 0.05 sec. Draw the profile of the cam if it rotates at a speed of 100 rpm in a clockwise direction	2,3
13	From the following data draw the profile of a Cam in which the follower moves with SHM during ascent while it moves with UADM during descent: Least radius of Cam =50mm;Angle of ascent =48 degree; Angle of descent=60 degree; Angle of dwell between ascent & descent =42 degree ; Lift of follower =40mm dia of roller=30 mm; Distance between line of action of the follower & axis of can=20 mm.	2,3
14	Draw the profile of a cam operating a knife edge having lift of 30 mm the cam rises the follower with SHM for $150^0$of its rotation followed by a period of dwell for 60^0. The follower descends for next 100^0 rotation of the cam with uniform velocity again followed by a dwell period. The cam rotates at a uniform velocity of 120 rpm and has a least radius of 20 mm what will be the max. Velocity and acceleration of follower during lift	2,3
15	A translating roller follower is offset to lift of the cam center by 15 mm. The cam has a base circle radius of 30 mm and follower has a lift of 40mm. Cam rotates clockwise.The follower has 150^0 uniform acceleration and retardation motion for the rise and dwell is 30^0. Roller radius is 5 mm. 150^0 SHM for return motion. Determine the required cam profile. Find the max. Velocity and acceleration of follower. Draw the respective diagrams.	2,3
16	Derive a equation for acceleration for arc of cam with flat faced follower	2,3

Module wise lesson plan

Course title and code: **Kinematics of Machines (15ME42)**	
Module 3	Planned Hours**: 10**

Learning Objectives:

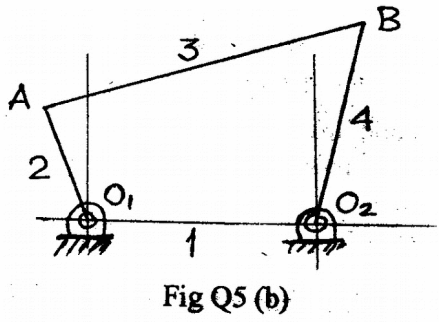
At the end of this chapter students will be able to,

- Compute the velocity and accelerations of the four bar chain and slider crank chain using analytical expression.(Complex algebra).
- Compute the velocity and accelerations the four bar chain and slider crank chain using analytical expression.(Vector algebra).

Lesson Schedule:

Lecture No	Topics Covered	Teaching Method	Po's Attained	Co's Attained	Reference Book/Chapter No
L41	Velocity and acceleration analysis of mechanisms analytical method): Analysis of four bar chain	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1,R2
L42	PROBLEMS	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1,R2
L43	PROBLEMS	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1,R2
L44	Slider crank chain usinganalyticalexpression use of complex algebra	Chalk & Board	a, e, h ,i	2,3	T1,T2,R1,R2
L45	PROBLEMS	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1,R2
L46	Freudenstein's Equation: Four bar & Slider crankMechanism	Chalk & Board	a, e, h ,i	2,3	T1,T2,R1,R2
L47	PROBLEMS	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1,R2
L48	Function Generation for Four bar Mechanism	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1,R2
L49	PROBLEMS	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1,R2
L50	PROBLEMS	Chalk & Board	a, e, h ,i	2,3	T1,T2 ,R1,R2

Assignment Questions:

Question Number	Assignment questions	COs attained
1	Obtain loop closure equation for a four bar mechanism	2,3
2	Explain the complex number method of velocity and acceleration analysis with suitable example	2,3
3	What is the significance of the loop closure equation in kinematics	2,3
4	For an IC engine mechanism, the crank radius is 100 mm and connecting rod length is 300 mm. The crank is rotating in clockwise direction with the angular velocity of 75 rad.sec and the angular acceleration of 1200 rad / sec. Find the acceleration of piston and angular acceleration of connecting rod when the crank is at 120 degree from the inner dead centre	2,3
5	Develop an equation for the relationship between the angular velocities of the input cranks and output cranks of the four bar linkage shown in figure Q5(b),using loop closure equation.  Fig Q5 (b)	2,3
6	Using complex algebra derive the expression for the velocity & acceleration of the piston, Angular acceleration of the connecting rod of reciprocating engine mechanism. With these expressions determine the above quantities, if crank length is 50 mm, Connecting rod 200mm, crank speed is constant at 3000rpm and crank angle is 30 degree.	2,3
7	In a 4 bar mechanism ABCD the link AB=300 mm , BC=360 mm, CD=360 mm & fixed link AD=600 mm, the angle of the link AB with the fixed link AD is 60 degrees. The link AB has an angular velocity of 10rad/sec & angular acceleration of 30rad/sec^2 both clockwise. Determine the angular velocity and angular acceleration of the link BC & CD by Raven's approach	2,3
8	In a slider crank mechanism the length of crank is 30 cm. Connecting rod has	2,3

	length of 120 cm. The crank position is 60 degree from IDC. Crank rotates with 500 rpm (clock Wise). Use analytical method and determine a) velocity of slider b) acceleration of slider c) angular velocity and angular acceleration of connecting rod.	

---:End of Kinematics of Machines Lesson Plan:--

Course Title: Applied Thermodynamics (15ME43)

2017-18

Department of: Mechanical Engg.												
Program: BE Mechanical												
Course Title: Applied Thermodynamics Course Code:15ME43 Theory: ☑ Practical: ☐												
Prerequisites to this course: (Course title with course codes)												
Program Outcomes (POs)	a	b	c	d	e	f	g	h	i	j	k	l	m
	✓	✓			✓						✓		
Mapping of Course Outcomes with Pos	1,2,3,4,5	1,2,3,4,5			1,2,3,4,5						1,3		
Course category	Basic		Gen	Core								Elective	

	Sciences	General Humanities eral/	G-A	G-B	G-C	G-D	G-E	G-F	
				✓					

Teaching Methods:	PPT	OHP	Face to Face	Guest Lecture	Video lecture	Demo (Lab visit)	Seminars	Industrial visits
Modules	I,III & V		I to V					

Continuous Assessment	Internal assessment tests	Assignment	Tutorial
	3	3	6

Contents beyond syllabus to meet POs:	Topics	POs attained
	1. 2. 3.	

Approved by:	Module Coordinator	Dr.R.G.Tikotkar
	Program coordinator	Prof.S.B.Koulagi

Achieving Intended Course Learning Outcomes

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

Sl.No.	Course Learning Outcomes	Possible capabilities, skills, expertise gained (codes)	Means of imparting the curriculum

1	CO1	Kn,Un	Class room Lectures
2	CO2	Kn,Un	Class room Lectures
3	CO3	PS,AS	Class room Lectures
4	CO4	AS,PSS	Class room Lectures
5	CO5	PSS,AS	Class room Lectures
Possible capabilities, skills, expertise gained			**Code**
Knowledge			Kn
Understanding (Comprehension)			Un
Problem solving skills (application skills)			PSS
Practical skills (application skills)			PS
Analytical skills			AS
Synthesis skills			SS
Written communication skills			WCS
Verbal/oral communication skills			VCS
Presentation skills			PS
Leadership skills			LS

Program Educational Objectives (PEOs)

The educational objectives of the Mechanical Engineering Program are to prepare our graduates to:

1. Establish a successful career in Mechanical Engineering or related fields in Industry and other organizations where an engineering approach to problem solving is highly valued.
2. Develop the ability among the students to synthesize the data and technical concepts for applications to the product design.
3. Contribute significantly in a multidisciplinary work environment with high ethical standards and with understanding of the role of engineering in economy and the environment.
4. Excel in graduate study and research, reaching advanced degrees in engineering and related disciplines.
5. Achieve success in professional development through life-long learning.

l. an ability to apply knowledge of mathematics, science, and Mechanical Engineering
m. an ability to design and conduct experiments, as well as to analyze and interpret data
n. an ability to design a mechanical system, mechanical component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
o. an ability to function on multidisciplinary teams
p. an ability to identify, formulate, and solve mechanical engineering problems
q. an understanding of professional and ethical responsibility
r. an ability to communicate effectively
s. the broad education necessary to understand the impact of mechanical engineering solutions in a global, economic, environmental, and societal context
t. a recognition of the need for, and an ability to engage in life-long learning,
u. a knowledge of contemporary issues
v. an ability to use the techniques, skills, and modern mechanical engineering tools necessary for engineering practice.

COURSE PLAN

Semester: IV **Year: 2017-18**

Subject: Applied Thermodynamics	**Subject Code: 15ME43**
Total no. of Hrs. 50	**IA Marks:20**
Exam Marks :80	**Exam Hours:03**
Lesson plan prepared by: Prof. V.C.Nirale, Prof R.S.Kondaguli, Prof. P.L.Puthani	
Credits:04	

COURSE CONTENT

Module -1 **Gas Power Cycles :**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. Gas turbine (Brayton) cycle; description and analysis. Regenerative gas turbine cycle. Inter-cooling and reheating in gas turbine cycles. Jet propulsion: Introduction to the principles of jet propulsion, turbojet, turboprop, Ramjet	**10 Hours**

and turbofan engines and their processes . Principles of rocket propulsion, Introduction to rocket engine.	
Module -2 **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, Binary Vapour cycles	**10 Hours**
Module -3 **Combustion Thermodynamics:** Theoretical (Stoichiometric) air for combustion of fuels. Excess air, mass balance, Exhaust gas analysis, A/F ratio. Energy balance for a chemical reaction, enthalpy of formation, enthalpy and internal energy of combustion. Combustion efficiency. Dissociation and equilibrium, emissions. **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. Automotive Pollutions and its effects on environment.	**10 Hours**
Module -4 **Refrigeration Cycles:** Vapour compression refrigeration system; description, analysis, refrigerating effect. Capacity, power required, units of refrigeration, COP, Refrigerants and their desirable properties, alternate Refrigerants. Any one case study on cold storage or industrial refrigerator. Air cycle refrigeration; reversed Carnot cycle, reversed Brayton cycle,Vapour absorption refrigeration system. Steam jet refrigeration. **Pscychrometrics and Air-conditioning Systems:** Properties of Atmospheric air, and 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 -5 **Reciprocating Compressors:** Operation of a single stage reciprocating compressors. Work input through p-v diagram and steady state steady flow analysis. Effect of Clearance and Volumetric efficiency. Adiabatic, Isothermal and Mechanical efficiencies. Multi-stage compressor, saving in work, Optimum intermediate pressure, Inter-cooling, Minimum work for compression. **Steam nozzles:** Flow of steam through nozzles, Shape of nozzles, effect of friction, Critical pressure ratio, Supersaturated flow.	**10 Hours**

Data Handbooks:

D1. **Thermodynamic data hand book,** B.T. Nijaguna.

D2. **Properties of Refrigerant & Psychometric** (tables & Charts in SI Units),

Dr. S.S. Banwait, Dr. S.C. Laroiya, Birla Pub. Pvt. Ltd., Delhi, 2008.

TEXT BOOKS:

T1. **Thermodynamics an engineering approach** by Yunus A. Cenegal and Michael A. Boles. Tata McGraw hill Pub. Sixth edition, 2008.

T2. **Basic and Applied Thermodynamics** by P .K. Nag, Tata McGraw Hill, 2nd Edi. 2009

T3. **Fundamentals of Thermodynamics** by G.J. Van Wylen and R.E. Sonntag, Wiley Eastern. Fourth edition 19993.

REFERENCE BOOKS:

R1. **Thermodynamics for engineers,** Kenneth A. Kroos and Merle C. Potter, Cengage Learning, 2016

R2. **Principles of Engineering Thermodynamics,** Michael J,Moran, Howard N. Shapiro, Wiley, th 8 Edition

R3. **An Introduction to Thermodynamics** byY.V.C.Rao, Wiley Eastern Ltd, 2003.

R4. **Thermodynamics** by Radhakrishnan. PHI, 2 revised edition.

R5. **I.C Engines** by Ganeshan.V. Tata McGraw Hill, 4rth Edi. 2012.

R6. **I.C.Engines** by M.L.Mathur& Sharma. DhanpatRai& sons- India

E-LEARNING

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

Scheme of Examination:

Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

Assessment	Marks
Internal Assessment tests	20
VTU Semester examination	80
Total	100

COURSE DESCRIPTION:

1. Overview of the Course:

Thermodynamics is the science of energy transfer and its effect on the physical properties of substances. Applied thermodynamics deals with application of knowledge of thermodynamics processes to different engineering systems. This course deals with study of Combustion thermodynamics**,** Gas Power Cycles, Vapour Power Cycles, Gas turbines and Jet Propulsion, Vapour Power Cycles, Reciprocating Compressors, Refrigeration, Psychometrics, and I.C. Engines.

2. Relevance of the course:

This course deals with the basic laws governing work transfer and heat transfer and their applications. The sound knowledge of this course is very much essential to study and understand the various subjects like Turbo-machines, Heat and Mass Transfer, theory of I.C. engines and power plant engineering in higher semesters of Mechanical Engineering program. Hence this course is a prerequisite to all the above said subjects and one of the important courses of the program.

3. Applications areas:

It has a broad application area ranging from microscopic organisms to common household appliances, transportation vehicles, power generation systems. Selected Areas of Application of Engineering Thermodynamics are listed as below:

- Automobile engines
- Turbines
- Compressors, pumps
- Fossil- and nuclear-fueled power stations
- Propulsion systems for aircraft and rockets
- Combustion systems
- Cryogenic systems, gas separation, and liquefaction
- Heating, ventilating, and air-conditioning systems
- Cooling of electronic equipment
- Alternative energy systems
- Biomedical applications

4. Prerequisites for the course:

This subject requires the students to know about the knowledge of engineering mathematics, basic thermodynamics.

5. Course Outcomes (COs): The student should be able to

1. Apply thermodynamic concepts to analyze the performance of gas power cycles including propulsion systems
2. Apply thermodynamic concepts to analyze vapour power cycles.
3. Understand combustion of fuels and combustion processes in I C engines including alternate fuels and pollution effect on environment.
4. Determine performance parameters of refrigeration and air-conditioning systems.
5. Apply thermodynamic concepts to analyze reciprocating air compressors & steam nozzles.

Module Wise Lesson Plan

Course title and code: Applied Thermodynamics, 15ME43	
Module : 01, Gas Power Cycles	**Planned Hours: 10**

Learning Objectives: At the end of this chapter the student will be able to

1. Explain Air standard Carnot, Otto, Diesel, Dual and Stirling cycles on P-v and T-s diagrams.
2. Evaluate efficiencies and mean effective pressures.
3. Compare Otto, Diesel and Dual cycle.
4. Analyze gas turbine (Brayton) cycle.
5. Describe Regenerative, Inter-cooling and Reheating in gas turbine cycles.
6. Explain the working of Jet propulsion, turbojet, turbo-prop, Ramjet turbofan engines & rocket propulsion.

Lesson Plan:

Lecture No.	Topics covered	Teaching Method	POs Attained	COs attained	Book/Chapter No.
L1	Gas power cycles: Air standard cycles. Carnot cycle	Chalk and Board	a,b,e	1	T1/9, T2/13&21, R3/9
L2	Otto cycle, Diesel cycle	Chalk and Board		1	T1/9, T2/13&21, R3/9
L3	Dual cycle, Stirling cycle	Chalk and Board		1	T1/9, T2/13&21, R3/9
L4	Comparison of Otto and Diesel cycles.	Chalk and Board		1	T1/9, T2/13&21, R3/9

L5	Numericals	Chalk and Board		1	T1/9, T2/13&21, R3/9
L6	Analysis of gas turbine	Chalk and Board		1	T1/9, T2/13&21, R3/9
L7	Regenerative, Inter-cooling	Chalk and Board		1	T1/9, T2/13&21, R3/9
L8	Reheating on gas turbines	Chalk and Board		1	T1/9, T2/13&21, R3/9
L9	Numericals, Jet propulsion, turbojet	Chalk Board & Ppt.		1	T1/9, T2/13&21, R3/9
L10	Turbo-prop, Ramjet turbofan engines & rocket propulsion.	Chalk Board & Ppt.		1	T1/9, T2/13&21, R3/9

Assignment:

	Questions:	COs attained
1.	Explain the following terms, with reference to engines: a) Clearance volume b) Swept volume c) Compression Ratio d) Mean effective pressure.	1
2.	Derive an expression for thermal efficiency, mean effective pressure and work output of Carnot power cycle.	1
3.	Explain the working of following air standard cycles with P-V and T-S diagrams and thus derive expressions for work output, mean effective pressure and thermal efficiency.	1

	a) Otto cycle b) Diesel cycle c) Dual cycle d) Stirling cycle	
4.	Compare Otto, Diesel and Dual cycles based on: a) Same compression ratios and heat rejection. b) Same max. temp. and pressure and heat rejection. c) Same compression ratios and heat addition. d) Same max. pressure and heat rejection.	1
5.	In a dual cycle the compression ratio is 14, maximum pressure is limited to 55 bar. The cut off ratio is 1.07. air is admitted at a pressure of 1 bar. Find the thermal efficiency and mean effective pressure.	1
6.	In an ideal diesel cycle initial pressure and temperature at the beginning of compression are respectively 0.98 bar and 35 degree centigrade. Assuming amass flow of 1kg/cycle and cut off ratio of 6% of the stroke volume determine compression ratio,% clearance, thermal efficiency and MEP if pressure at the end of compression is 33 bar.	1
7.	Discuss the effect of Regeneration of Brayton cycle efficiency. Define the effectiveness of regenerator.	1
8.	With necessary T-S diagram & devices layout diagrams explain the working of Brayton cycle with regeneration, inter cooling and reheat.	1
9.	Explain the principles & working of i) Jet propulsion ii) Turbo jet iii) Turbo prop iv) Ram jet v) Turbo fan engine vi) Rocket propulsion	
10.	Determine the power output, efficiency, and specific fuel consumption of a gas turbine using 4.5 kg/s of air under following condition. The isentropic efficiencies of turbines and compressor are 85% each. Inlet conditions are 1bar and 27^0C. Assume C_p=1.005KJ/kg K, γ= 1.4 for compression and C_p=1.088kJ/kgK, γ= 1.35 for combustion and expansion processes. Lower heat value =41870 KJ/kg.	1
11.	In a gas turbine plant the air enters at pressure and temperature of 1 bar and 27 degree centigrade. The ratio of maximum pressure is 3.5 and the temperature of the gas before expansion is 700 degree centigrade. If the isentropic efficiency of the compressor and turbine are 0.80 and 0.85 respectively, determine the overall efficiency of the cycle and percentage change in efficiency of the plant if a regenerator of 0.6 effectiveness is added to the plant.	1

Module Wise Lesson Plan

Course title and code: Applied Thermodynamics, 15ME43	
Module: 02, Vapour Power Cycles	**Planned Hours: 07**

Learning Objectives: At the end of this chapter the student will be able to

1. Discuss Carnot vapour power cycle and drawbacks as a reference cycle
2. Explain the Rankine cycle on T – s and P-V diagrams.
3. Explain the analysis for performance and comparison of Carnot and Rankine cycles.
4. Describe the effects of pressure and temperature on Rankine cycle performance.
5. Explain Ideal and practical regenerative Rankine cycles
6. Explain Reheat Rankine cycle.
7. Describe the working of open and closed feed water heaters.
8. Explain the working of Binary vapour cycles.

Lesson Plan:

Lecture No.	Topics covered	Teaching Method	POs Attained	COs attained	Book/Chapter No.
L11	Vapour power cycles: Carnot vapour power cycle. Drawbacks as reference cycle.	Chalk and Board	a,b,e	2	T1/10, T2/12, R3/9
L12	Simple Rankine cycle;	Chalk and		2	T1/10, T2/12,

	description, T-s diagrams. analysis for performance	Board			R3/9
L13	Analysis for performance , comparison of Carnot and Rankine cycles	Chalk and Board		2	T1/10, T2/12, R3/9
L14	Effects of pressure and temperature on Rankine cycle performance.	Chalk and Board		2	T1/10, T2/12, R3/9
L15	Actual vapour power cycles	Chalk and Board		2	T1/10, T2/12, R3/9
L16	Ideal and practical regenerative Rankine cycles.	Chalk and Board		2	T1/10, T2/12, R3/9
L17	Open and closed feed water heaters	Chalk and Board		2	T1/10, T2/12, R3/9
L18	Numericals	Chalk and Board		2	T1/10, T2/12, R3/9
L19	Numericals	Chalk and Board		2	T1/10, T2/12, R3/9
L20	Characteristics of an Ideal working fluid in Vapour power cycles, Binary Vapour cycles	Chalk and Board		2	T1/10, T2/12, R3/9

Assignment:

Questions:		COs attained
1.	Develop, P-V, T-S & h-S diagram for a reversible cycle that represents the simple steam power plant.	2
2.	Derive an expression for work ratio and cycle efficiency of an ideal Rankine cycle.	2
3.	Discuss the effect of Super heat – increasing temperature at turbine inlet at constant pressure.	2

	Increase in pressure at turbine inlet at same max. temperature. on the cycle efficiency of Rankine cycle.	
4.	Discuss the effect of regeneration on the a) Specific output. b) Mean temperature of heat addition. c) Cycle efficiency. d) Steam Rate e) Heat rate of a steam power plant.	2
5.	Write the characteristics of an Ideal working fluid in Vapour power cycles.	2
6.	Describe Binary Vapour cycles.	
7.	Steam enters the turbine of a steam power plant, operating on a Rankine cycle, at 10bar and 300^0C. The condenser pressure is 0.1bar. Stem leaving is 90% dry. Calculate the adiabatic efficiency of the turbine and the cycle efficiency neglecting the pump work.	
8.	The net power output in an ideal reheat-regenerative cycle is 100MW. Steam the HP turbine at 90 bar, 550°C. After expansion to 7 bar, some of the steam goes to an open heater and the balance is reheated to 400°C, after which it expands to 0.07 bar. What is the steam flow rate to HP turbine? What is total pump work? Calculate the cycle efficiency. If there is 100% rise in the temperature of the cooling water, what is the rate of flow of cooling water in the condenser? If the velocity of the steam from the turbine to condenser is limited to 130 m/s, find the diameter of the connecting pipe.	2
9.	A steam power plant operates with an initial pressure of 20 bar and temperature of 400°C, and exhaust to pressure of 2 bar. The condensate from the heating system is returned to boiler at 65°C, and the heating system utilizes for its intended purpose 90% of the energy transferred from steam it receives. The turbine efficiency is 70%. What is the fraction of energy supplied to the steam plant serves as useful purpose? If two separate steam power plants are setup same useful energy, one to generate heating steam at 2 bar, and other to generate power through a cycle working between 20 bar, 400°C and 0.07 bar, what fraction of the energy supplied would have served a useful purpose?	2

Module Wise Lesson Plan

Course title and code: Applied Thermodynamics, 15ME43	
Module : 03, Combustion Thermodynamics	**Planned Hours: 07**

Learning Objectives: At the end of this chapter the student will be able to

1. Explain theoretical (Stoichiometric) air for combustion of fuels.
2. Define excess air, mass balance.
3. Discuss exhaust gas analysis.
4. Describe A/F ratio, Energy balance for a chemical reaction, enthalpy of formation, enthalpy and internal energy of combustion.
5. Explain combustion efficiency, dissociation, equilibrium & emissions.
6. Discuss combustion in SI & CI engines, detonation and factors affecting detonation.
7. Evaluate Performance of I.C Engines, solve related numerical problems on heat balance sheet and Morse test
8. Describe IC Engine fuels, Ratings, Alternate Fuels, Automotive Pollutions and their effects on environment.

Lesson Plan:

Lecture No.	Topics covered	Teaching Method	POs Attained	COs Attained	Book/Chapter No.
L21	Combustion thermodynamics:- A/F ratio, Theoretical (stoichiometric) air for combustion of fuels, excess air, mass balance	Chalk and Board	a,b,k	3	T1/15, T2/16&20, R6/ (5,6,8,9,18 & 20)
L22	Exhaust gas analysis, A/F ratio	Chalk and Board		3	T1/16, R1/15
L23	Energy balance for a chemical reaction	Chalk and Board		3	T1/16, R1/15
L24	Enthalpy of formation and internal energy of combustion	Chalk and Board		3	T1/15, T2/16&20, R6/ (5,6,8,9,18 & 20)
L25	Combustion efficiency. Dissociation and equilibrium, emissions.	Chalk and Board		3	T1/15, T2/16&20, R6/ (5,6,8,9,18 & 20)

L26	Classification, Combustion of SI engine and CI engine, Detonation and factors affecting detonation	Chalk Board & Ppt.		3	T1/15, T2/16&20, R6/ (5,6,8,9,18 & 20)
L27	Performance analysis of I.C Engines, heat balance, Morse test	Chalk and Board		3	T1/15, T2/16&20, R6/ (5,6,8,9,18 & 20)
L28	Numerical Problems	Chalk and Board		3	T1/15, T2/16&20, R6/ (5,6,8,9,18 & 20)
L29	Numerical Problems, IC Engine fuels & ratings	Chalk Board & Ppt.		3	T1/15, T2/16&20, R6/ (5,6,8,9,18 & 20)
L30	Alternate Fuels, Automotive Pollutions and its effects on environment	Chalk Board & Ppt.		3	T1/15, T2/16&20, R6/ (5,6,8,9,18 & 20)

Assignment:

	Questions:	COs attained
1.	With reference to combustion, explain stoichiometric air & excess air.	3
2.	Explain the analysis of exhaust gases using Orsat apparatus with a neat sketch	3
3.	With reference to combustion, explain the following: i) Internal energy of combustion. ii) Enthalpy of combustion. iii) Enthalpy of formation. iv) Heat of reaction	3
4.	A sample of fuel has the following percentage composition: Carbon=86%, Hydrogen=8%, Sulphur =3%, Oxygen=2%, Ash=1%. For an air-fuel ratio of 12:1 calculate mixer strength as percentage of	3

	rich or week and volumetric analysis of the dry products of combustion.	
5.	A fuel gas has following percentage volumetric analysis. H_2 : 48, CH_4: 26, CO_2: 11, CO:5, N_2:10 The percentage volumetric analysis of the dry exhaust gases is CO_2:8.8, O_2:5.5, N_2:85.7. Determine air fuel ratio by volume if air contains 21% of O_2 by volume.	3
6.	The fuel has following percent analysis by weight. C: 82, H_2:10, S: 3, O_2:2.5, Ash: 2.5. For an air fuel ratio of 12.1, calculate the mixture strength as percentage rich or lean and the volumetric analysis of the dry products of combustion. Air contains 23% of O_2 by weight.	3
7.	The composition of dry flue gases obtained by burning the liquid fuel containing only hydrogen and carbon is CO_2: 10.7%, O_2: 5.1%, N_2: 84.2%. Calculate the composition of the fuel by weight and the excess air used.	3
8.	Explain combustion in SI engine and CI engines	3
9.	Explain BP of multi cylinder engine by Morse test?	3
10.	Define detonation and describe the factors affecting detonation	3
11.	Write short notes on i) IC Engine fuels & their ratings ii) Alternate Fuels iii) Automotive Pollutions and its effects on environment.	3
12.	In a test on tree cylinder four stroke IC engine with 22cm bore 26cm stroke the following were the observations during a trial of one hour. Fuel used = 8.0kg, CV= 45MJ/kg, Total revolutions of the crankshaft=12000, MEP=6bar, Net load on brake drum=1.5KN, Brake drum dia.=1.8m, rope dia.=3cm, Mass of cooling water =550kg, inlet temperature of cooling water=27^0C, Exit temperature of cooling water=55^0C,Air consumed=300kg, Room temp.=30^0C, Exhaust gas temp.=310^0C,specific heat of exhaust gasses=1.1kJ/kgK. Calculate IP,BP, Mechanical efficiency, Indicated efficiency. Also draw heat balance sheet.	3

13.	The following data refer to test conducted on a two stroke diesel engine run for 20 minutes at full load. MEP=3 bar, speed=350 rpm, net brake load= 0.65KN, fuel consumption = 1.52 kg, water out let temp.=52^{o}C, water in let temp.=30^{o}C, air/fuel ratio=32, room temp.=25^{o}C, exhaust temp.=300oC, bore=20cm, stroke=28cm, brake drum dia.=100cm, CV of fuel=44000kJ/kg, steam formed per kg of fuel in exhaust=1.35kg, C_p of steam = 2.09 KJ/kgK, C_p of dry exhaust gasses=1.0KJ/kgK. Draw heat balance sheet.	3

Module Wise Lesson Plan

Course title and code: Applied Thermodynamics, 15ME43	
Module Number : 04, Refrigeration Cycles	**Planned Hours: 10**

Learning Objectives: At the end of this chapter the student will be able to

1. Describe the principle of Vapour compression refrigeration system.
2. Explain refrigerating effect, capacity, power required, units of refrigeration.
3. Explain COP. Refrigerants and their desirable properties.
4. Describe the principle of Air cycle refrigeration; reversed Carnot cycle, reversed Brayton cycle
5. Explain the principle vapour absorption refrigeration system, steam jet refrigeration.
6. Define Psychrometric properties; Dry bulb temperature, wet bulb temperature, dew point temperature; partial pressures, specific and relative humidifies.
7. Discuss the construction and use of Psychrometric chart.
8. Explain the analysis of various processes; heating, cooling, dehumidifying and humidifying. Adiabatic mixing of stream of moist air.
9. Explain the working of summer and winter air - conditioning.
10. Describe the working of cooling towers.

Lesson Plan:

Lecture	Topics covered	Teaching	POs	COs	Book/Chapter

No.		Method	attained	attained	No.
L31	Refrigeration: Vapour compression refrigeration system. Description	Chalk and Board		4	T1/(11&14), T2 /(14 & 15) R3/ (9 &10)
L32	Analysis, refrigerating effect,	Chalk and Board		4	T1/(11&14), T2 /(14 & 15) R3/ (9 &10)
L33	COP. Refrigerants and their desirable properties	Chalk and Board		4	T1/(11&14), T2 /(14 & 15) R3/ (9 &10)
L34	Air cycle refrigeration; reversed Carnot cycle, reversed Brayton cycle.	Chalk and Board		4	T1/(11&14), T2 /(14 & 15) R3/ (9 &10)
L35	Vapour absorption refrigeration system .steam jet refrigeration	Chalk and Board		4	T1/(11&14), T2 /(14 & 15) R3/ (9 &10)
L36	Numerical problems	Chalk and Board	a,b,e,	4	T1/(11&14), T2 /(14 & 15) R3/ (9 &10)
L37	Psychrometric properties, construction and use of Psychrometric chart	Chalk and Board		4	T1/(11&14), T2 /(14 & 15) R3/ (9 &10)
L38	Heating, cooling, dehumidifying and humidifying. Adiabatic mixing of stream of moist air.	Chalk and Board		4	T1/(11&14), T2 /(14 & 15) R3/ (9 &10)
L39	Working of air-conditioners & cooling towers	Chalk Board & Ppt.		4	T1/(11&14), T2 /(14 & 15) R3/ (9 &10)
L40	Numerical problems	Chalk and Board		4	T1/(11&14), T2 /(14 & 15) R3/ (9 &10)

Assignment:

<table>
<tr><th colspan="2">Questions:</th><th>COs attained</th></tr>
<tr><td>1.</td><td>With P-V and T-S diagram explain reversed Brayton cycle working as a refrigeration cycle and hence derive an expression for its COP.</td><td>4</td></tr>
<tr><td>2.</td><td>With flow, T-S, h-S, P-h diagram explain the working of vapour compression refrigeration cycle and hence derive an expression for COP.</td><td>4</td></tr>
<tr><td>3.</td><td>Discuss the effect of following factors on the performance of Vapour compression refrigeration cycle.
i) Sub cooling of liquid.
ii) Super heating of vapour.
iii) Change in suction pressure.
iv) Change in discharge pressure.</td><td>4</td></tr>
<tr><td>4.</td><td>With flow diagram explain the working of vapour absorption refrigeration cycle.</td><td>4</td></tr>
<tr><td>5.</td><td>Discuss desirable properties of an ideal refrigerant.</td><td>4</td></tr>
<tr><td>6.</td><td>A refrigerating machine working on reversed Carnot cycle consumes 6KW for producing refrigerating effect of 1000KJ per minute for maintaining a region at -40^0C. Determine i) higher temperature of the cycle ii) COP of the cycle iii) when this device is used as a heat pump, what will be the heat delivered.</td><td>4</td></tr>
<tr><td>7.</td><td>20 tonnes of ice is produced in a day of 24 hours from water at 20°C to ice at -6°C. The temperature change in the compressor is from -15°C to 25°C. The condition of the vapour at the compression is dry and saturated. Assuming relative COP as 80%, calculate the power required to drive compressor. C_p for ice as 2.1kJ/kg, latent heat of ice is 335 kJ/kg. Use the following properties of refrigerant.
<table>
<tr><th rowspan="2">Temp.°C</th><th colspan="2">Liquid</th><th colspan="2">Vapour</th></tr>
<tr><th>Enthalpy kJ/kg</th><th>Entropy kJ/kgK</th><th>Enthalpy kJ/kg</th><th>Entropy kJ/kgK</th></tr>
<tr><td>25</td><td>100.04</td><td>0.347</td><td>1319.2</td><td>4.4852</td></tr>
<tr><td>-5</td><td>-54.55</td><td>-2.1338</td><td>1304.99</td><td>5.0585</td></tr>
</table></td><td>4</td></tr>
<tr><td>8.</td><td>Explain adiabatic saturation process and hence define adiabatic saturation temperature.</td><td>4</td></tr>
<tr><td>9.</td><td>Describe psychometric chart? Plot the skeleton of this chart showing</td><td>4</td></tr>
</table>

	various parameters represented on it.	
10.	With necessary sketches explain the processes of humidification & dehumidification.	4
11.	With necessary sketches explain the process of cooling and dehumidification.	4
12.	With necessary sketches explain the process of heating and humidification.	4
13.	With flow diagram explain simple summer air conditioning system.	4
14.	With flow diagram explain simple summer air conditioning system.	4
15.	Describe the working of cooling towers.	4
16.	Air at 30^0C and RH 60%, specific volume 0.8808 m3/kg, enthalpy 71.2kJ/kg flows over a cooling coil at 250 m3/min from the charts the corresponding due point is 21.5^0C. After flowing over the coil the temperature reduces to 23^0C with enthalpy 64.2kJ/kg. Sketch the process on the psychrometric chart. Determine cooling coil capacity.	4
17.	An air conditioning plant is to be designed for a small office room for winter conditions. Outdoor conditions are 10°C DBT and 8°C WBT. Required indoor conditions are 20°C and 60% RH. Amount of free air circulation is 0.3 m^3/min./person. Sitting capacity of the office is 50. The required condition is achieved by frit heating and then by adiabatic humidification. Find out the following (a) capacity of the heating coil and the surface temp. if by-pass factor of the coil is 0.32 (b) the capacity of humidifier.	4

Module Wise Lesson Plan

Course title and code: Applied Thermodynamics, 15ME43	
Module : 05 - Reciprocating compressors	**Planned Hours: 10**

Learning Objectives: At the end of this chapter the student will be able to

1. Explain the Operation of a single stage reciprocating compressors.
2. Develop the work input through P – v diagram.
3. Describe the effect of clearance and volumetric efficiency.

4. Explain Adiabatic, isothermal and mechanical efficiencies.
5. Explain the Operation of a multi stage reciprocating compressors.
6. Describe optimum intermediate pressure, inter-cooling, minimum work for compression.
7. Explain flow of steam through nozzles, Shape of nozzles.
8. Explain the effect of friction, Critical pressure ratio & Supersaturated flow.

Lesson Plan:

Lecture No.	Topics covered	Teaching Method	POs Attained	Cos Attained	Book/Chapter No.
L41	Reciprocating compressors: operation of a single stage reciprocating compressor.	Chalk and Board	b,e	5	T1/7, T2/(17 &19)
L42	Work input through p-v diagram and steady state steady flow analysis.	Chalk and Board		5	T1/7, T2/(17 &19)
L43	Effect of clearance and volumetric efficiency. Adiabatic, isothermal & mechanical efficiencies	Chalk and Board		5	T1/7, T2/(17 &19)
L44	Multi stage compressor, saving in work	Chalk and Board		5	T1/7, T2/(17 &19)
L45	Optimum intermediate pressure inter-cooling minimum work for compression	Chalk and Board		5	T1/7, T2/(17 &19)
L46	Minimum work for compression	Chalk and Board		5	T1/7, T2/(17 &19)
L47	Numerical problems	Chalk and Board		5	T1/7, T2/(17 &19)
L48	Flow of steam through	Chalk and		5	T1/7,

	nozzles, Shape of nozzles	Board			T2/(17 &19)
L49	Effect of friction, Critical pressure ratio & Supersaturated flow	Chalk and Board		5	T1/7, T2/(17 &19)
L50	Numericals.	Chalk and Board		5	T1/7, T2/(17 &19)

Assignment:

Questions:		COs attained
1.	Derive an expression for work required for single stage air compressor with clearance when the compression and expansion follow PV^n = constant.	5
2.	Define and explain volumetric efficiency. Derive an expression for volumetric efficiency in terms of pressure ratio, Polytropic index and clearance ratio.	5
3.	Describe inter-cooling in multistage reciprocating air compressor? Explain its effect on its performance. What do you mean by perfect inter cooling?	5
4.	In two stage compressor, show that the work done is minimum with perfect inter cooling when the intermediate pressure is the geometric mean suction and delivery pressure. $P_i = \sqrt{P_s . P_d}$.	5
5.	Define nozzle & write the classification of nozzles.	5
6.	Derive an expression for critical pressure ratio in convergent- divergent nozzle. Explain choking in nozzles.	5
7.	Discuss effect of friction i) Flow through steam nozzles ii) Pressure ratio	5
8.	Explain supersaturated phenomena using h-s & t-s diagrams.	5
9.	A single stage single acting reciprocating air compressor 30cm bore 40cm stoke is running at speed of 100rpm. It takes in air at 1bar and 20^0C and compresses it to pressure of 5bar. Find the power required to drive it when the compression is i) isothermal , ii) $PV^{1.2}$=C and	5

	iii) Adiabatic. Also find the isothermal efficiency. Neglect clearance.	
10.	A two stage air compressor draws air from 17°C and 1 bar. The air is cooled in the inter cooler to 30°C and intermediate pressure of 7.7 bar. The low pressure is 10cm diameter and the stroke for both the cylinders is 11.25cm. Assuming compression law of $Pv^{1.35}$= constant, and the volume of drawn in per stroke is equal to the low pressure cylinder swept volume, find the power of the compressor while running at 250 rpm. Find also the diameter of the HP cylinder.	5

Semester – IV

Course Title: Fluid Mechanics (15ME44)

Department of: Mechanical						
Program: BE Mechanical						
Course Title: Fluid Mechanics Course Code: 15ME44 Theory: √ Practical: ☐						
Prerequisites to this course: (Course title with course codes)						

Program Outcomes (POs)	a	b	c	d	E	f	g	h	i	j	k	l	m
	x		x	x	X			x			x	-	-
Mapping of Course Outcomes with Pos	1 to 5	1 to 5			1 to 5			1 to 5			1 to 5	-	-

Course category	Basic Sciences	General/ Humanities General	Core						Elective
			G-A	G-B	G-C	G-D	G-E	G-F	
				X					

Teaching Methods:	PPT	OHP	Face to Face	Guest Lecture	Video lecture	Demo (Lab visit)	Seminars	Industrial visits
Module	I, II, IV, V		I,II,III,IV, V		I, II, III, IV		I, II	

Continuous Assessment	Internal assessment tests	Assignment	Tutorial
	3	3	

Contents beyond syllabus to meet POs:	Topics	POs attained
	1. 2. 3.	

Approved by:	Module Coordinator	Dr. R.G.Tikotkar
	Program coordinator	Prof. S.B.Koulagi

Achieving Intended Course Learning Outcomes

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

Sl.No.	Course Learning Outcomes	Possible capabilities, skills, expertise gained (codes)	Means of imparting the curriculum
1	CO1	Kn, Un	
2	CO2	Un, PSS	
3	CO3	PSS, AS	
4	CO4	PSS, AS	
5	CO5	AS, PS	

Possible capabilities, skills, expertise gained	**Code**
Knowledge	Kn
Understanding (Comprehension)	Un
Problem solving skills (application skills)	PSS
Practical skills (application skills)	PS
Analytical skills	AS

Synthesis skills	SS
Written communication skills	WCS
Verbal/oral communication skills	VCS
Presentation skills	PS
Leadership skills	LS

Program Educational Objectives (PEOs)

The educational objectives of the Mechanical Engineering Program are to prepare our graduates to:

6. Establish a successful career in Mechanical Engineering or related fields in Industry and other organizations where an engineering approach to problem solving is highly valued.
7. Develop the ability among the students to synthesize the data and technical concepts for applications to the product design.
8. Contribute significantly in a multidisciplinary work environment with high ethical standards and with understanding of the role of engineering in economy and the environment.
9. Excel in graduate study and research, reaching advanced degrees in engineering and related disciplines.
10. Achieve success in professional development through life-long learning.

Program outcomes (POs)

w. an ability to apply knowledge of mathematics, science, and Mechanical Engineering
x. an ability to design and conduct experiments, as well as to analyze and interpret data
y. an ability to design a mechanical system, mechanical component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
z. an ability to function on multidisciplinary teams
aa. an ability to identify, formulate, and solve mechanical engineering problems
bb. an understanding of professional and ethical responsibility
cc. an ability to communicate effectively
dd. the broad education necessary to understand the impact of mechanical engineering solutions in a global, economic, environmental, and societal context
ee. a recognition of the need for, and an ability to engage in life-long learning,
ff. a knowledge of contemporary issues
gg. an ability to use the techniques, skills, and modern mechanical engineering tools necessary for engineering practice.

COURSE PLAN

Semester: IV **Year: 2016 -17**

Subject: Fluid Mechanics	**Subject Code: 15ME44**
Total Teaching Hours: 50	**I A Marks:20**
Exam Marks: 80	**Exam Hours: 03**
Lesson Plan Prepared by: Prof. S.A.Biradar **Prof. P.V.Goggal** **Prof. A.M.Tamagond**	**Date: 23/01/2017**

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 center of pressure for horizontal plane, vertical plane surface and inclined plane surface submerged in static fluid. Buoyancy, center of buoyancy, meta center and meta centric height its application in shipping, stability of floating bodies.

10 Hours

Module -2 Fluid Kinematics and Dynamics:

Fluid Kinematics: Types of Flow-steady, unsteady, uniform, non-uniform, laminar, turbulent,

one, two and three dimensional, compressible, incompressible, rotational, irrotational, stream lines, path lines, streak lines, velocity components, convective and local acceleration, velocity

Potential, stream function, continuity equation in Cartesian co-ordinates. Rotation, vorticity and

circulation, Laplace equation in velocity potential and Poisson equation in stream function, flow net, Problems.

Fluid Dynamics:

Momentum equation, Impacts of jets- force on fixed and moving vanes, flat and curved. numericals. Euler's equation, Integration of Euler's equation to obtain Bernoulli's equation, Bernoulli's theorem, Application of Bernoulli's theorem such as venture meter, orifice meter, rectangular and triangular notch, pitot tube, orifices etc., related numericals.

12 Hours

Module -3

Laminar and turbulent flow: Reynods 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,related numericals.

Energy consideration in pipe flow, Loss of Pressure Head due to Fluid Friction, DarcyWeishach

formula, major and minor losses in pipes,Commercial pipe, Colebrook equation,

Moody equation/ diagram. Pipes in series, parallel, equivalent pipe, Related Numericals and

Simple pipe design problems.

10 Hours

Module -4

Flow over bodies: Development of boundary layer**,** Prandtl'sboundary layer equations, Blasius solution, and laminar layer over a flat plate, boundary layer separation and its control.

Basic concept of Lift and Drag, Types of drag, Co-efficient of drag and lift, streamline body and bluff body, flow around circular bodies and airfoils, Lift and drag on airfoil, Numericals.

Dimensional analysis: Need for dimensional analysis, Dimensions and units, Dimensional Homogeneity and dimensionless ratios, methods of dimensional analysis, Rayleigh's method, Buckingham Pi theorem, Similitude and Model studies. Numericals.

10 Hours

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.

8 Hours

TEXT BOOKS:

T1 Fluid Mechanics (SI Units), Yunus A. Cengel John M.Cimbala, 3rd Ed., Tata McGraw Hill, 2014.

T2 Fluid Mechanics, F M White, McGraw Hill Publications Eighth edition. 2016

T3 Mechanics of Fluids, Merle C. Potter, Devid C. Wiggerrt, Bassem H. Ramadan, Cengage learning, Fourth editions 2016.

REFERENCE BOOKS:

R1 Fundamentals of Fluid Mechanics by Munson, Young, Okiishi& Huebsch, John Wiley Publications.7th edition.

R2 Fluid Mechanics, Pijush.K.Kundu, IRAM COCHEN, ELSEVIER, 3rd Ed. 2005.

R3 Fluid Mechanics, John F.Douglas, Janul and M.Gasiosek and john A.Swaffield,Pearson Education Asia, 5th ed., 2006.

R4 Introduction to Fluid Mechanics by Fox, McDonald, John Wiley Publications,8th edition.

Scheme of Examination:

Assessment	Marks
Internal Assessment tests	20
VTU Semester examination	80
Total	100

1. Prerequisites

This subject requires the knowledge of Applied Mechanics, Mathematics, Physics and Basic Thermodynamics.

2. Course Description

i. Overview of the course:

The contents of the course "Fluid Mechanics (FM)" is designed by the members of the Board of Studies (BoS) constituted by Visveswaraya Technological University (VTU) Belgaum. Basically, FM course deals with the study of behavior of fluids at rest and as well as in motion:

ii. Course Learning Objectives (CLO's):

The student will be able to

1. Acquire the knowledge of the fluid properties.
2. Apply the Pascal's law and hydrostatic law in pressure measurement and submerged surfaces.
3. Apply the Archimedes' principle in Buoyancy concept.
4. Identify the types of fluid flows.
5. Apply the Bernoulli's and Euler's Equation in motion of fluid.
6. Use different fluid flow meters to determine discharge.
7. Use Buckingham π theorem for dimensional analysis.

8. Measure the losses in fluid flow through pipes.
9. Use Hagen- Poiseille's equation laminar flow.
10. Identify fluid flow past immersed bodies to study the Drag, Lift etc., and understand introductory concept of incompressible flow.

iii. Course outcomes (CO's)

The student will be able to

CO1: Identify and calculate the key fluid properties used in the analysis of fluid behavior. Understand and apply the principles of pressure, buoyancy and floatation

CO2: Apply the knowledge of fluid statics, kinematics and dynamics while addressing problems of mechanical and chemical engineering.

CO3:Understand and apply the principles of fluid kinematics and dynamics.

CO4:Understand the concept of boundary layer in fluid flow and apply dimensional analysis to form dimensionless numbers in terms of input output variables.

CO5: Understand the basic concept of compressible flow and CFD

iv) Relevance of the Course

Fluid Flow occurs in all fields of our natural and technical environment. Without fluid flows life, as we know it, would not be possible on Earth, nor could technological processes run in the form known to us and lead to the multitude of products which determine the high standard of living that we nowadays take for granted. Flows are therefore vital.

Flows are everywhere and there are flow-dependent transport processes that supply our body with the oxygen that is essential to life. In the blood vessels of the human body, essential nutrients are transported by mass flows and are thus carried to the cells, where they contribute, by complex chemical reactions, to the build-up of our body and to its energy supply. Similarly to the significance of fluid flows for the human body, the multitude of flows in the entire fauna and flora are equally important. Without these flows, there would be no growth in nature and human beings would be deprived of their "natural food". Life in Nature is thus dependent on flow processes and understanding them is an essential part of the general education of humans.

The course on FM is a prerequisite to many mechanical engineering courses such as Turbo machines, Hydraulics & pneumatics Heat & Mass Transfer etc.

V) Application areas:

Fluid mechanics is widely used both in everyday activities and in the design of modern engineering systems from vacuum cleaners to supersonic aircraft. Therefore, it is important to develop a good understanding of the basic principles of fluid mechanics.

To begin with, fluid mechanics plays a vital role in the human body. The heart is constantly pumping blood to all parts of the human body through the arteries and veins, and the lungs are the sites of airflow in alternating directions. Needless to say, all artificial hearts, breathing machines, and dialysis systems are designed using fluid dynamics.

An ordinary house is, in some respects, an exhibition hall filled with applications of fluid mechanics. The piping systems for cold water, natural gas and sewage for an individual house and the entire city are designed primarily on the basis of fluid mechanics. The same is also true for the piping and ducting network of heating and air-conditioning systems. A refrigerator involves tubes, through which the refrigerant flows, a compressor that pressurizes the refrigerant, and two heat exchangers where the refrigerant absorbs and rejects heat.

Fluid mechanics plays a major role in the design of all these components. Even the operation of ordinary faucets is based on fluid mechanics. We can also see numerous applications of fluid mechanics in an automobile. All components associated with the transportation of the fuel from the fuel tank to the cylinders—the fuel line, fuel pump, fuel injectors, or carburetors—as well as the mixing of the fuel and the air in the cylinders and the purging of combustion gases in exhaust pipes are analyzed using fluid mechanics.

Fluid mechanics is also used in the design of the heating and air-conditioning system, the hydraulic brakes, the power steering, automatic transmission, and lubrication systems, the cooling system of the engine block including the radiator and the water pump, and even the tires. The sleek streamlined shape of recent model cars is the result of efforts to minimize drag by using extensive analysis of flow over surfaces.

On a broader scale, fluid mechanics plays a major part in the design and analysis of aircraft, boats, submarines, rockets, jet engines, wind turbines, biomedical devices, the cooling of electronic components, and the transportation of water, crude oil, and natural gas. It is also considered in the design of buildings, bridges, and even billboards to make sure that the structures can withstand wind loading. Numerous natural phenomena such as the rain cycle, weather patterns, and the rise of ground water to the top of trees, winds, ocean waves, and currents in large water bodies are also governed by the principles of fluid

mechanics.

Natural flows and weather
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Human body
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Cars
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Wind turbines
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Piping and plumbing systems
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Industrial applications
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Module wise lesson plan

Course title and code: Fluid Mechanics -15ME44	
Module 1: Basics & Fluid Statics	**Planned hours: 10**

Learning objectives:

1. To define and classify fluids.
2. To study the significance of fluid properties like: viscosity, density, specific gravity etc.
3. To study the concept of surface tension, capillarity, vapors pressure, compressibility bulk modulus, concept of continuum.
4. To study and understand Pascal's law.
5. To study different units of pressure and the techniques of pressure measurement, to study different types of Manometers.
6. To compute the hydrostatic forces on submerged bodies; that help in the design of structures like dams, ships & hydraulic actuators (gates).
7. To study the Principle of Buoyancy.
8. To analyze the stability of Floating bodies; importance of metacentric height under & its application in shipping.

Lesson Schedule:

Lecture No	Topics covered	Teaching Method	PO's Attained	CO's Attained	Reference Books/ Chapter No
L1	Description about fluid, types of fluids, Defns: Density, Sp.weight, Sp.volume & Sp. gravity and numericals.	Chalk And Board, PPT	a,b,c,e	1	T1/1,2,3 T2/1,2 R2/1
L2	Viscosity, compressibility & Bulk modulus, Surface tension & Capillarity.	Chalk And Board		1	T1/1,2,3 T2/1,2 R2/1
L3	Concept of continuum, fluid pressure at a point, Pascals law, pressure variation in the static fluid.	Chalk And Board		1	T1/1,2,3 T2/1,2 R2/1
L4	Absolute, Gauge, Atmospheric & Vacuum pressure Measurement of Pressure	Chalk And Board, PPT		1	T1/1,2,3 T2/1,2 R2/1
L5	Simple manometer, Differential Manometer, Numerical.	Chalk And Board, Video		1	T1/1,2,3 T2/1,2 R2/1
L6	Total pressure and Centre of pressure, Horizontal and Vertical plane surface submerged in liquid. Problems.	Chalk And		1	T1/1,2,3 T2/1,2

		Board			R2/1
L7	Inclined plane surface submerged in liquid, problems.	Chalk And Board		1	T1/1,2,3 T2/1,2 R2/1
L8	Buoyancy, center of buoyancy, metacenter and metacentric height,	Chalk And Board	a,b,c,e	1	T1/1,2,3 T2/1,2 R2/1
L9	Conditions of equilibrium of floating and submerged bodies	Chalk And Board		1	T1/1,2,3 T2/1,2 R2/1
L10	Stability of floating bodies, Numericals	Chalk And Board, Video		1	T1/1,2,3 T2/1,2 R2/1

Assignment questions:

1.	Define the terms associated with fluid: 1. Density 2.Sp Weight 3.Sp Volume 4. Sp Gravity.	1
2.	Define the term Viscosity. State the Newton's Law of Viscosity.	1
3.	Define Surface tension. Prove that the relationship between surface tension and pressure inside a droplet of liquid in excess of pressure is given by $p= 4\sigma/d$.	1
4.	Explain the phenomenon of capillarity. Obtain an expression for capillary rise of a liquid.	1
5.	At a certain point in castor oil film, the shear stress is 0.2 N/ m2 and the velocity gradient is 0.216 s-1. If the mass density is 959.42 kg/ m3, find the kinematic viscosity of the oil. [Jan 2005, 1(c)].	1
6.	Two horizontal plates are placed 1.25 cm apart and the intermediate space is filled with an oil of viscosity 14 poise. Calculate the shear stress in the oil if the upper plate is moved with a velocity of 2.5 m/ s. [July 2005, 1 (c)]	1
7.	State and prove Pascal's law.	1
8.	With a neat line representations explain the terms: a) Absolute Pressure. b) Gauge Pressure & c) Vacuum Pressure.	1
9.	A certain fluid of specific gravity 0.8 flows upwards through a vertical pipe. A and B are two points on the pipe, B being 0.3 m higher than A. A U-tube mercury manometer is connected at gage points A and B; if the difference of pressure between A and B is 0.18 N/ m^2, find the	1

	reading shown by the manometer. [Jan 2005, 2 (b)].	
10.	An annular plate 3 m external diameter and 1.5 m internal diameter is immersed in water with its greatest and least depths below water surface at 3.6 m and 1.2 m respectively. Determine the total pressure and the position of the centre of pressure on one face of the plate.[jan 2010 2(c)].	1
11.	Define the term buoyancy and center of buoyancy	1
12.	What are the conditions of equilibrium of a floating body and a submerged body.	1

Module wise lesson plan

Course title and code: Fluid Mechanics -15ME44	
Module 2: Fluid Kinematics and Dynamics.	**Planned hours: 12**

Learning objectives

1. To study types of flow, steady, unsteady, uniform, nonuniform, laminar, turbulent, 1-D,2-D & 3-D
2. To study the concept of stream lines, streak lines & path lines, velocity components.
3. To study continuity equation in Cartesian co-ordinate.
4. To get the concept of velocity potential, stream function & flow net.
5. To study the fluid motion; that involves forces of action and reaction.
6. To study the Laplace equation in velocity potential and poisson equation in stream function.
7. To study momentum equation, impact of jets, numericals.
8. To obtain the governing equation for an ideal fluid flow; Euler's equation of motion.
9. To understand the use and limitations of the Bernoulli equation, and its application to solve a variety of fluid flow problem.
10. To study application of Bernoulli's theorem such as venture meter, orifice meter, notches, pitot tube etc.

Lesson Schedule:

Lecture No	**Topics covered**	**Teaching Method**	**PO's Attained**	**CO's Attained**	**Reference Books/ Chapter No**
L11	Different types of flow, steady, unsteady, uniform, nonuniform, etc.	Chalk And Board, PPT		2	T1/4,5, 8,9 R2/3
L12	Study of streak lines, stream lines, path lines, velocity components, convective &local acceleration.	Chalk And Board		2	T1/4,5, 8,9 R2/3
L13	Velocity potential, stream function, Continuity equation in 3-dimensions	Chalk And Board,		2	T1/4,5, 8,9 R2/3

	[Cartesian coordinate system only].	PPT	a,b,c,e		
L14	Rotation, vorticity and circulation. Introduction to Laplace equation & Poisson equation in stream function.	Chalk And Board		2	T1/4,5, 8,9 R2/3
L15	Introduction to momentum equation, impact of jets on force on fixed and moving vanes.	Chalk And Board, Video		2	T1/4,5, 8,9 R2/3
L16	Introduction, equations of motion, Euler's equation of motion, numericals.	Chalk And Board		2	T1/4,5, 8,9 R2/3
L17	Bernoulli's equation from first principle.	Chalk And Board		2	T1/4,5, 8,9 R2/3
L18	Bernoulli's equation from Euler's equation, Problems. Bernoulli's theorem.	Chalk And Board		2	T1/4,5, 8,9 R2/3
L19	Applications of Bernoulli's equation, numericals.	Chalk And Board		2	T1/4,5, 8,9 R2/3
L20	Flow measuring device such as venture meter, orifice meter.	Chalk And Board, Video		2	T1/4,5, 8,9 R2/3
L21	Notches, rectangular & triangular	Chalk And Board		2	T1/4,5, 8,9 R2/3
L22	Pitot tube, orifices, etc Numericals	Chalk And Board		2	T1/4,5, 8,9 R2/3

Assignment:

1.	Define kinematics of flow. What are the different methods of describing fluid motion?	2
2.	Define the following types of line: i) Path line ii) stream line iii) Stream tube iv) Potential Function, v) Streak or filament line.	2
3.	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.	2
4.	What do you mean by velocity potential function and stream function? Also write their properties.	2
5.	Describe in brief Flow net.	2

6.	Define convective and local acceleration. Find the acceleration components at a point (1, 1, 1) in a flow field described by $u = 2x^2 + 2y$, $v = -2xy + 3y^2 + 3yz$ and $w = 3/2\ z^2 + 2xz - 9y^2z$. [July 2005, 4(c)].	2
7.	Derive Euler's equation along a stream line and reduce it to Bernoulli's equation & state the assumptions made.	2
8.	What is Venturimeter? Derive an expression for the discharge through a Venturimeter.	2
9.	Explain the impact of jets on fixed and moving vanes.	2
10.	Derive the velocity potential from Laplace equation.	2

Module wise lesson plan

Course title and code: Fluid Mechanics -15ME44	
Module 3: Laminar & turbulent flow and Energy consideration in pipe flow	**Planned hours: 10**

Learning objectives:

1. To realize the significance of Bernoulli's equation in practical applications.
2. To establish the Hagen Poiseulle's equation for laminar flow in a pipe.
3. To derive an expression for velocity and pressure distributions for two-dimensional laminar flow between two stationary parallel flat plates.
4. To understand the scope of Darcy-Weisbach & Chezy's empirical relations to determine head loss.
5. To study and determine the major and minor energy losses.
6. To understand the terms hydraulic gradient and total energy line.
7. To study and understand laminar and turbulent flows.
8. To study and understand simple pipe design

Lesson Schedule:

Lecture No	**Topics covered**	**Teaching Method**	**PO's Attained**	**CO's Attained**	**Reference Books/ Chapter No**
L23	Reynolds's number.Critical Reynolds's number & Reynolds experiment.	Chalk And Board, Video	a,b,c,e	3	T1/5,7,8 R2/9

L24	Navier- Stokes Equation (no derivation), Laminar flow between parallel and stationary plates. Problems	Chalk And Board		3	T1/5,7,8 R2/9
L25	Laminar flow through a round pipe. Hagen Poiseulle's equation. Numerical	Chalk And Board		3	T1/5,7,8 R2/9
L26	Minor losses through pipes,	Chalk And Board		3	T1/5,7,8 R2/9
L27	Problems.	Chalk And Board		3	T1/5,7,8 R2/9
L28	Darcy's and Chezy's equations for loss of head due to friction in pipes.	Chalk And Board		3	T1/5,7,8 R2/9
L29	HGL and TEL, Problems.	Chalk And Board, Video		3	T1/5,7,8 R2/9
L30	Colebrook equation, Moody equation/ diagram.	Chalk And Board		3	T1/5,7,8 R2/9
L31	Pipes in series, parallel, equivalent pipe, Related Numerical	Chalk And Board		3	T1/5,7,8 R2/9
L32	Simple pipe design problems.	Chalk And Board		3	T1/5,7,8 R2/9

Assignment questions:

1.	How will you determine the loss of head due to friction in pipes by using I) Darcy formula and ii) Chezy's formula.	3
2.	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.	3
3.	Define and explain the terms: i) Hydraulic gradient line and ii) Total energy line.	3
4.	Explain the term pipes in parallel. How discharge through the main pipe is increased by connecting pipes in parallel.	3
5.	Water of kinematic viscosity 9.29×10^{-7} m^2/s flows in a cylindrical pipe of 5 cm diameter. Calculate the largest flow rate for which laminar flow can be expected take critical Re=2100.[jan	3

	2010]	
6.	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
7.	Prove that maximum velocity in a circular pipe for viscous flow is equal to two times the average velocity of the flow.	3
8.	**What is Hagen Poisenille's formula? Drive an expression for Hagen Poisenille's formula.**	3
9.	Prove that the velocity distribution for a 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. [July 2006, 7 (b)].	3
10.	Oil is to be transported from a tanker to the shore at a rate of 0.006 m^3/ sec using a pipe of 32 cm diameter for a distance of 20 kms. If oil has viscosity 0.1 Nm/sec^2 and density 900 kg/ m^3. Calculate the power necessary to maintain the flow. [July 2005, 7 (b)].	3
11.	An oil of viscosity 0.1 Ns/m^2 and relative density 0.9 is flowing through a circular pipe of diameter 50 mm and length 300 m. The rate of flow of fluid through the pipe is 3.5 lps. Find the pressure drop in a length of 300 m and also the shear stress at the pipe wall.	3
12.	Oil of relative density 0.9 and dynamic viscosity 2.5 poise is pumped through a 100 mm diameter pipe 500 m long at a rate of 2 lps.Find the Reynolds no of the flow 2. Calculate the Power required at the pump, if the outlet end which is free at 20 m above the pump level. 3. What should be the power input if the overall efficiency of pump set is 65%.	3

Module wise lesson plan

Course title and code: Fluid Mechanics - 15ME44	
Module 4: Flow over bodies & Dimensional analysis effects	**Planned hours: 10**

Learning objectives:

1. To study and describe the terms drag and lift.
2. To learn about the concepts of Pressure drag, Friction drag, and flow separation.
3. To realize the significance of boundary layer concept in practical applications.
4. To understand various terminologies used in boundary layer flow.
5. To analyze basic equations governing compressible flow.
6. To define Mach No. and types of fluid flows depending on Mach number.
7. To understand dimensions, units, and dimensional homogeneity of equations.
8. To study the various methods of dimensional analysis.
9. To know how to use the method of repeating variables to identify non dimensional parameters

Lesson Schedule:

Lecture No	Topics covered	Teaching Method	PO's Attained	CO's Attained	Reference Books/ Chapter No
L33	Development of boundary layer**,** Prandtl'sboundary layer equations,	Chalk And Board	a,b,c,e	4	T1/10, 11 T2/5,7 R2/6
L34	Blasius solution, laminar layer over a flat plate, boundary layer separation and its control.	Chalk And Board		4	T1/10, 11 T2/5,7 R2/6
L35	Drag, Lift, expression for drag and lift.	Chalk And Board, PPT, Video		4	T1/10, 11 T2/5,7 R2/6
L36	Displacement thickness ,Momentum thickness,	Chalk And Board, PPT		4	T1/10, 11 T2/5,7 R2/6
L37	Problems	Chalk And Board		4	T1/10, 11 T2/5,7 R2/6
L38	Introduction, derived quantities. Dimensions of physical quantities.	Chalk And Board		4	T1/10, 11 T2/5,7 R2/6
L39	Dimensional homogeneity, Raleigh's method, Buckingham's π theorem, problems.	Chalk And Board, PPT		4	T1/10, 11 T2/5,7 R2/6
L40	Dimensionless numbers, Similitude.	Chalk And Board		4	T1/10, 11 T2/5,7 R2/6
L41	Types of Similitudes	Chalk And Board, PPT		4	T1/10, 11 T2/5,7 R2/6
L42	Problems	Chalk And Board		4	T1/10, 11 T2/5,7 R2/6

Assignment questions:

1.	Distinguish between Form & skin friction drag, Lift & drag force, Physical significance of	4

	displacement thickness & momentum thickness.	
2.	Define drag force & lift force. Also derive their expressions.	4
3.	Derive an expression for displacement thickness & momentum thickness of a flow over a plate.	4
4.	Sketch the nature of propagation of disturbance in compressible flow when Mach no. is more than one and hence define Mach angle and Mach cone.	4
5.	Explain briefly what is meant by sonic velocity and Mach number.	4
6.	Derive an expression for the velocity of sound wave for the compressible fluid and adiabatic process.	4
7.	Experiments were conducted in a wind tunnel with a wind speed of 50 km/h on a flat plate of size 2 m long and 1 m wide, The specific weight of air is 11.282 N/ m^3. The plate is kept at such an angle that the coefficients of lift and drag are 0.75 and 0.15 respectively. Determine (i) Lift force (ii) Drag force (iii) Resultant force (iv) Power excited by air stream on the plate. [Jan 2005, 8 (a)].	4
8.	Crude oil of specific gravity 0.85 and bulk modulus of 150000 N/cm^2,(ii) Mercury having a bulk modulus of 2600000 N/cm^2. [July 2006, 6 (c)].	4
9.	Determine the velocity of the bullet fired in the air if Mach angle is observed to be 30^0.Given: temperature of air 22^0C, Density 1.2 kg/m^3, γ=1.4 and R =287.4 j/kg k.	4
10.	An aero plane is flying at a height of 15 km where the temperature is -50^0C. The speed of the plane is corresponding to M= 2.0. Assuming K= 1.4 and R= 287 j/kg K, find the speed of the plane.	4
11.	Assuming that the rate of discharge Q of a hydraulic machine is dependent upon the mass density ρ of the fluid, speed of the machine N, diameter of the impeller D, pressure p and viscosity μ , show using Buckingham's π theorem that it can be represented by $Q = ND^3\Phi \{ 9H / N^2D^2, v / ND^2 \}$, H being the head and v the kinematic viscosity of the fluid. [Jan 2005, 5 (a)]. Jan 2010 4 (b)	4
12.	State Buckingham's π theorem and show that the velocity through circular orifice is given by $V = \sqrt{2gH}\ \Phi \{ D/H, \mu/ \rho VH\}$ where H is the head causing flow, D the diameter of the orifice, μ is the absolute viscosity , ρ the fluid of the mass density of the fluid and g the acceleration due to gravity. [July 2005, 5 (a)]. The inlet and throat diameters of a vertically mounted venturimeter are 300 mm and 100 mm respectively. The throat is below the inlet at a distance of 100 mm. The mass density of the liquid is 900 kg/ m^3. The pressure intensity at the inlet is 140 kPa while at the throat is 80 kPa. Calculate the flow rate. Assume that 2 % of the differential head is lost between the inlet and the throat. [Jan 2005, 6 (a)].	4

Module wise lesson plan

Course title and code: Fluid Mechanics - 15ME44

Module 5 : Compressible flows and Introduction to CFD	**Planned hours: 08**

Learning objectives:

1. To list fluid properties associated with compressible flow.
2. To compute the Mach number and use its value to correctly identify the flow regime.
3. To Evaluate the isentropic relationships for the stagnation properties
4. To use computational techniques to solve problems related to flow mechanics.

Lecture No	**Topics covered**	**Teaching Method**	**PO's Attained**	**CO's Attained**	**Reference Books/ Chapter No**
L43	Introduction, thermodynamic relations of perfect gases,	Chalk And Board	a,c,e,h,k	5	T1/12,15 T2/9 R2/16
L44	Internal energy and enthalpy, speed of sound	Chalk And Board		5	T1/12,15 T2/9 R2/16
L45	Pressure field due to a moving source, basic Equations for one dimensional flow	Chalk And Board		5	T1/12,15 T2/9 R2/16
L46	Stagnation and sonic Properties	Chalk And Board		5	T1/12,15 T2/9 R2/16
L47	Normal and oblique shocks	Chalk And Board		5	T1/12,15 T2/9 R2/16
L48	**Introduction to CFD**: Necessity, limitations	Chalk And Board,PPT		5	T1/12,15 T2/9 R2/16
L49	Philosophy behind CFD	Chalk And Board		5	T1/12,15 T2/9 R2/16
L50	Applications of CFD	Chalk And Board,PPT		5	T1/12,15 T2/9 R2/16

Assignment questions:

1.	Write a note on normal and oblique shocks.	5

2.	What is CFD? What are the advantages and limitations?	5
3.	Write the applications of CFD.	5
4.	Sketch the nature of propagation of disturbance in compressible flow when Mach no. is more than one and hence define Mach angle and Mach cone.	5
5.	Explain briefly what is meant by sonic velocity and Mach number.	5
6.	Derive an expression for the velocity of sound wave for the compressible fluid and adiabatic process.	5
7.	Derive the continuity equation for one dimensional compressible fluid for i)Isothermal process ii)adiabatic process	5
8.	A supersonic plane travels at 1.6 Mach at an altitude of 20 km above the ground. How far ahead the plane will be when one hears the sonic boom on the ground? [Jan 2005, 7 (c)].	5
9.	Compute the velocity of a bullet fired in still air, with a mach angle of 30^0. Take R = 287.14 J/kg^{0}k and γ = 1.4. Assume air temperature to be 15^0 C. [July 2005, 7 (d)].	5
10.	Determine the velocity of the bullet fired in the air if Mach angle is observed to be 30^0.Given: temperature of air 22^0C, Density 1.2 kg/m^3, γ=1.4 and R =287.4 j/kg k.	5

… End of FM Lesson Plan …

COURSE PLAN

Semester: III **Year: 2017-18**

Subject: METAL CASTING AND WELDING	**Subject Code: 15ME35A**
Total No. of Lecture Hours: 50	**I A Marks : 20**
Exam Marks: 80	**Exam Hours: 03**
Lesson plan prepared by : Prof. A.D. Talikoti	**Date: 06/09/2016**

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

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.

Question paper pattern:

- 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.

Prerequisites:

The student should have studied the course "Elements of Mechanical Engineering, Chemistry, Physics and Mathematics"

Overview of the Course:

The course content is planned to provide knowledge and skill required to become an efficient Engineer by keeping the lesions related to production field.

1. Basic understanding of various dimensions and functions of the production field as whole.
2. Analytical skill needed to tackle the ever-changing problems and situations modern competitive production.
3. To take appropriate decision for reasoning and supported by tools used in production process.

Course Outcomes (CO):

After a successful completion of the course, the student will be able to:

1 Describe the casting process, preparation of Green, Core, dry sand molds and Sweep, Shell, Investment and plaster molds.

2 Explain the Pattern, Core, and Gating, Riser system and Jolt, Squeeze, Sand Singer Moulding Machines.

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

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

5 Explain the Solidification process and Casting of Non-Ferrous Metals.

6 Describe the Metal Arc, TIG, MIG, Submerged and Atomic Hydrogen Welding Processes used in manufacturin.

7 Explain the Resistance spot, Seam, Butt , Projection, Friction, Explosive, Thermit, Laser and Electron Beam Special type of welding process used in manufacturing.

8 Describe the Metallurgical aspects in Welding and inspection methods for the quality

assurance of components made of casting and joining process.

Relevance of the Course:

The detail understanding of manufacturing process like casting and welding is essential for every engineer. This will help the students to utilize appropriate capabilities, advantages and also limitations of the process. This in turn helps in proper design of any product. Further able to assess feasibility of manufacturing, to find more than one processes available to manufacture the product. Thus it helps to choose the proper process which requires the lowest manufacturing cost and deliver the product to the customer of desired quality.

In this course the students able to study and understand two main processes namely casting and fabrication. In casting process, the liquid metal is used. It requires cavity preparation for the final object to be made. Molten metal is poured into the mould cavity and allowed to solidify and the object removed is called casting. In fabrication process involves joining of two pieces permanently or temporarily. The joining is achieved by either heat or pressure.

Application Areas:

The subject finds application in foundry and fabrication industries. The main objective of the subject to bring the awareness of castings and metal joining processes like welding.

The real time applications are

1. Foundry shop
2. Fabrication shop
3. Production industries
4. Workshop.
5. Electronic and electrical industries.

Unit wise plan

Course Title / Code: Metal casting and welding (15ME35A)	
Module No.: 1. INTRODUCTION & BASIC MATERIALS USED IN FOUNDRY	**Planned Hours: 10**

Learning Objectives:

At the end of the chapter the student should be able to:

1. Explain the classification of various manufacturing processes in order to produce the components of required specifications.
2. Identify various steps involved in making a casting processes and its advantages, limitations and applications.
3. Analyze types of patterns materials and its functions.
4. Prepare the allowances provided to design a pattern in order to produce a casting of proper size and shape.
5. Predict various additives and binders and their importance.
6. Explain molding sand ingredients used to prepare sand molds in order to obtain the desired component by casing.
7 Predict the various desirable properties of the molding sand to obtain the castings of high quality.
8. Analyze the core, its need and manufacture.
9. Design and prepare the gating system.
10 . Explain molding sand ingredients used to prepare sand molds in order to obtain the desired component by casing.
11 Predict the various desirable properties of the molding sand to obtain the castings of high quality.
12 Analyze the core, its need and manufacture
13 Design and prepare the gating system

Lesson Plan:

Lesson. No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter no.
L1	Definition, Classification of manufacturing processes. Metals cast in the foundry-classification, factors that determine the selection of a casting alloy.	Chalk and Board		1	T1, R2
L2	Introduction to casting process & steps involved. Patterns: Definition, classification, materials used for pattern, various pattern allowances and their importance.	Chalk and Board		1	T1, R2
L3	Types of base sand, requirement of base sand. Binder, Additives definition, need and types	Chalk and Board		1	T1, R2
L4	Molding machines- Jolt type, squeeze type and Sand slinger.	Chalk and Board	k	1	T1, R
L5	Study of important molding process: Green sand, core sand, dry sand, sweep mold	Chalk and Board		2	T1/6, R2/10
L6	CO2 mold, shell mold,	Chalk and Board		2	T1, R2
L7	Investment mold, plaster mold,	Chalk and Board		2	T1,R1
L8	cement bonded mold.Cores:	Chalk and Board		2	T1,R1
L9	Cores: Definition, need, types. Method of making cores	Chalk and Board		2	T1,R1
L10	concept of gating (top, bottom, parting line, horn gate) and risering (open, blind) Functions and types	Chalk and Board		2	T1,R1

Assignment Questions	COs attained
1. Define casting. Enumerate different steps involved in producing a component by casting process.	1

2. Mention the advantages of casting in comparison with other manufacturing processes.	1
3. Explain the terms pattern, core, mould and casting in casting process.	1
4. With neat sketches explain different types of patterns and mention their applications.	1
5. Define a pattern. Differentiate between a casting and pattern.	1
6. What are the common materials used for pattern making? Discuss their relative merits and demerits.	1
7. What are the factors which govern the selection of a proper material for pattern making?	1
8. Enumerate and briefly explain various pattern allowances.	1
9 Briefly explain the desirable properties of foundry sand.	2
10 What are the requirements of molding sand?	2
11 What are the ingredients of molding sand? Explain the importance of each of them in brief.	2
12 Explain the various additives used in molding sand clearly indicating how it is used to improve the properties.	2
13 Briefly explain the mechanism of bonding in clay bonded sands.	2
14 List the important tests performed on foundry sands. Explain one of the tests in detail.	2
15 What is permeability of molding sands? Explain briefly how it is determined.	2
16 What are cores? Briefly explain their importance in sand molding process.	2
17 Mention the desirable properties of cores.	2
18 What are the ingredients of core sand? Explain the importance of each of them in brief.	2
19 Mention the various additives used in core sand and indicate the properties achieved by them.	2
20Briefly explain the various steps involved in a core making process.	2
21With simple sketches explain the different types of cores used in sand molding.	2
22 Briefly explain the different varieties of baked cores based on the type of binder used.	2
23 What are no-bake cores? List their advantages over baked cores.	2

Unit wise plan

Course Title / Code: METAL CASTING AND WELDING (15ME35A)	
Module No.: 2. Melting and Metal mold casting methods	**Planned Hours: 10**

Learning Objectives:

At the end of the chapter the student should be able to:

1 Identify the classify the melting furnaces
2 Identify the important factors in the selection of a furnace.
3 Prepare the advantages and disadvantages of crucible furnaces.
4 Explain working principles electric or furnace and their constructional features
5 Explain the working principle of induction furnace and classification and their constructional feature

Lesson Plan:

Lesson. No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter no.
L11	Classification of furnaces, Gas fired pit furnace, Resistance furnace,	Chalk and Board	c, k	2	T1,T2
L12	electric arc furnace, constructional features of cupola furnace.	Chalk and Board		2	T1,R2
L13	working principle of cupola furnace.	Chalk and Board		2	T1,T2
L14	Gravity die casting,	Chalk and Board		2	T1,R2
L15	centrifugal casting.	Chalk and Board		2	T1,T2
L16	squeeze casting, SLUSH CASTING	Chalk and Board		2	T1,R2
L17	Thixocasting, Gas fired pit furnace	Chalk and Board		2	T1,T2
L18	continuous casting processes working	Chalk and Board		2	T1,R2
L19	pressure die casting	Chalk and Board		2	T1,T2
L20	Coreless induction furnace	Chalk and Board		2	T1,R2

Assignment Questions	CO's attained
1. Mention the factors to be considered in the selection of a suitable melting furnace.	3
2. What are the different types of crucible furnaces? With a sketch explain the	3

principle of operation of a gas fired pit furnace.	
3. With a sketch explain the operation of a high frequency induction furnace.	3
4. What are the differences between core type and coreless type induction furnaces?	3
5. With a neat sketch explain the operation of an indirect arc furnace. How does it differ from a direct arc furnace?	3
6. With a neat sketch explain the operation of cupola furnace.	3
7. Draw the neat sketch of a cupola showing the constructional details. Mark the different zones clearly and discuss the importance of each zone.	3
8. Draw a simple sketch and write a brief note on cupola charge.	3
9. Write the different reactions taking place in various zones of a cupola.	3
10. List the different methods of molding used in foundry practice. Briefly discuss with simple sketches.	3
11 Explain the working of the squeeze type of molding machine. Indicate how the mold hardness varies with the height of the box.	3
12. With a simple sketch explain the working of a sand slinger. What are its advantages compared to other molding machines?	4
13. With necessary sketches, briefly explain steps involved in the green sand molding process. List the advantages of limitations of the process. Compare the dry sand molding and skin dried molding process.	4
14. With neat sketches briefly explain the different steps involved in shell molding process.	4
15 List the advantages and limitations of shell molding process.	4
16 Explain the setting reaction in CO_2-sodium silicate process.	4
17 With simple sketches, briefly explain steps involved in the Full mold (lost foam) process. List the advantages of limitations of the process.	4
18 Briefly discuss important molding process considerations.	4

Unit wise plan

Course Title / Code: Metal casting and welding (15ME35A)	
Module No.: 3. SOLIDIFICATION & NON FERROUS FOUNDRY PRACTICE	**Planned Hours: 10**

Learning Objectives:

At the end of the chapter the student should be able to:

1 Learn about need of Nucleation, Directional solidification etc
2 understand Degasification in liquid metals
3 Explain the cleaning and fettling operation in casting
4 Analyze sand casting defects. cause as well as defects
5 Explain the melting of Aluminum crucible furnace.

Lesson Plan:

Lesson. No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter no.
L21	**Solidification**: Definition, Nucleation, solidification variables,.	PPT	h, k	5	T1,R2
L22	Directional solidification-need and methods	PPT		5	T2,R2
L23	Degasification in liquid metals	Chalk and Board		5	T1,R2
L24	**Fettling and cleaning of castings:** Basic steps involved. Sand Casting defects- causes	Chalk and Board		5	T2,R2
L25	features and remedies	Chalk and Board		5	T1,R2
L26	Advantages & limitations of casting process	Chalk and Board		5	T2,R2
L27	**Nonferrous foundry practice**: Aluminum castings - Advantages, limitations	Chalk and Board		5	T2,R2
L28	melting of aluminum using lift-out type crucible furnace.	Chalk and Board		5	T1,R2
L29	Hardeners used, drossing, gas absorption, fluxing and flushing, grain refining, pouring temperature	Chalk and Board		5	T1,R2
L30	Stir casting set up, procedure, uses, advantages and limitations	Chalk and Board		5	T2,R2

Assignment Questions	COs attained
1. List the different methods of molding used in foundry practice. Briefly discuss with simple sketches.	3
2. Explain the working of the squeeze type of molding machine. Indicate how the mold hardness varies with the height of the box.	3
3. With a simple sketch explain the working of a sand slinger. What are its advantages compared to other molding machines?	3
4. With necessary sketches, briefly explain steps involved in the green sand molding process. List the advantages of limitations of the process. Compare the dry sand molding and skin dried molding process.	3
5. With neat sketches briefly explain the different steps involved in shell molding process.	3
6. List the advantages and limitations of shell molding process.	3
7. Explain the setting reaction in CO_2-sodium silicate process.	3
8. With simple sketches, briefly explain steps involved in the Full mold (lost foam) process. List the advantages of limitations of the process.	3
9. Briefly discuss important molding process considerations.	3

Unit wise plan

Course Title / Code: Metal casting and welding (15ME35A)	
Module No.: 4. WELDING PROCESS	**Planned Hours: 10**

Learning Objectives:

At the end of the Unit, the student should be able to;

1. Demonstrate the welding process, classification, applications, advantages and limitations.
2 Analyze the principle of metal arc welding, Flux shielded metal arc welding, inert gas

welding (TIG & MIG) submerged Arc Welding (SAW), Atomic Hydrogen Welding.
3 Utilize equipments used for the above welding processes.
4 Apply applications of various welding processes.
5 Demonstrate the working principle of Oxy – Acetylene welding and their flames.
6 Utilize equipments and accessories used for gas welding processes.

Lesson Plan:

Lesson. No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter no.
L31	**Welding process:** Definition, Principles, Classification,	PPT	j, k	6	T1,T2
L32	Constructional features and working principle	PPT		6	T1,T2
L33	Metal arc welding (MAW), Flux Shielded Metal Arc Welding (FSMAW),	PPT		6	T1,T2
L34	Inert Gas Welding (TIG & MIG) Submerged Arc Welding (SAW)	Chalk and Board		6	T1,T2
L35	Atomic Hydrogen Welding (AHW).	Chalk and Board		7	T1,T2
L36	**Special type of welding:** Resistance welding principles, Seam welding, Butt welding,	Chalk and Board		7	T1,T2
L37	, Spot welding and Projection welding	Chalk and Board		7	T1,T2
L38	Friction welding, Explosive welding	Chalk and Board		7	T1,T2
L39	Thermit welding, Laser welding	Chalk and Board		7	T1,T2
L40	electron beam welding.	Chalk and Board		7	T1,T2

	COs attained
1. What is the working principle of arc welding?	6
2. Explain clearly the functions of flux in welding	6
3. Explain straight polarity and reverse polarity	6
4. Write a note on the of electrodes	6
5. Write a brief note on weld pattern used in arc welding	6
6. Explain with a neat sketch submerged arc welding process, mentioning its advantages and limitations.	6
7. Explain with a neat sketch flux-cored arc welding process, and bring out its advantages and limitations.	7
8. What is inert gas welding? Explain with a neat sketch the TIG welding Process. Mention its advantages and limitations.	7
9. How is the MIG welding different from the TIG welding? Explain.	7
10. Briefly explain the atomic hydrogen welding process	7
11 . What are special welding processes? How they are classified? Give examples of such process.	7
12 With a neat sketch explain thermit welding process. List the advantages and limitations of the process.	7
13. With a neat sketch explain the electron beam welding process. Mention the advantages and limitations of the process.	7
14 With a neat sketch explain the laser beam welding process. Mention the advantages and limitations of the process.	7
15 with a neat sketch explain the friction welding process. Mention the advantages, limitations and applications of the process.	7
16. with a neat sketch explain the explosive welding process. Mention the advantages, limitations and applications of the process.	7
17. Explain in brief spot welding, seam welding and Mention the advantages, limitations and applications of the process.	7
18. Give the classification of Resistance welding.	7

Unit wise plan

Course Title / Code: Metal casting and welding (15ME35A)	
	Planned Hours:10

MODULE -5 SOLDERING , BRAZING AND METALLURGICAL ASPECTS IN WELDING	

Learning Objectives:

At the end of the Unit, the student should be able to;

1. Explain the formation of different zones during welding and the different temperatures in the zones.
2. Identify the heat affected zone (HAZ) and various parameters affecting (HAZ).
3. Predict the shrinkage in welds and residual stresses.
5. Assess the concept of electrodes, filler rod and fluxes.
6. Identify the welding defects – detection causes and remedies.

Lesson Plan:

Lesson. No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter no.
L41	Structure of welds, Formation of different zones during welding, Heat Affected Zone (HAZ)	Chalk and Board	b, e, k	8	T1,T2
L42	Parameters affecting HAZ. Effect of carbon content on structure and properties of steel	Chalk and Board		8	T1,T2
L43	, Shrinkage in welds& Residual stresses, Concept of electrodes, filler rod and fluxes. Welding defects-Detection, causes & remedy	Chalk and Board		8	T1,T2
L44	**Soldering, brazing, gas welding:** Soldering, Brazing, Gas Welding:	Chalk and Board		8	T1,T2
L45	Principle, oxy-Acetylene welding, oxy-hydrogen welding, air-acetylene welding,	Chalk and Board		7	T1,T2
L46	Gas cutting, powder cutting.	Chalk and		7	T1,T2

		Board			
L47	**Inspection methods:** Methods used for inspection of casting and welding.	Chalk and Board		7	T1,T2
L48	Visual, magnetic particle, fluorescent particle, ultrasonic.	Chalk and Board		7	T1,T2
L49	Radiography, eddy current,	Chalk and Board		7	T1,T2
L50	holography methods of inspection.	Chalk and Board		7	T1,T2

Assignment Questions	COs attained
1. What is mean by soldering, explain the different methods	8
2. What is mean by brazing	8
3. Explain Principle, oxy-Acetylene welding with neat sketch	8
4. Explain Principle, oxy-hydrogen welding with neat sketch	8
5. Explain in detail Radiography, eddy current, tests	8
6. Explain in detail holography test.	8
7. Write short notes on “Inspection of casting and welding”	8
8. Draw the neat sketch showing different	8
9. Explain the details HAZ and its various regions.	8
10. What is residual stress? State the methods to reduce welding stesses.	8
11. Write a note on welding defects with their causes and remedies.	8
12. Discuss the need for the Flux,Filler material, Electrodes.	8

THE END

Syllabus for the internal Assessment Tests (Tentative):

Test	Units/Modules	COs attained
Internal Assessment Test-I	Module 1	1,2
Internal Assessment Test-II	Module 2,3	3,4,5
Internal Assessment Test-III	Module 4,5	6,7,8
Test pattern: Three questions will be given and students have to answer any two full questions. Each question carries 10 marks.		

Evaluation Scheme:

Assessment	Marks

Internal Assessment tests	20
VTU Semester examination	80
Total	100

Course Title: MACHINE TOOLS AND OPERATIONS (15ME35B)
2017-18

Program Educational Objectives (PEOs)

The educational objectives of the Mechanical Engineering Program are to prepare our graduates to:

6. Establish a successful career in Mechanical Engineering or related fields in Industry and other organizations where an engineering approach to problem solving is highly valued.
7. Develop the ability among the students to synthesize the data and technical concepts for applications to the product design.
8. Contribute significantly in a multidisciplinary work environment with high ethical standards and with understanding of the role of engineering in economy and the environment.
9. Excel in graduate study and research, reaching advanced degrees in engineering and related disciplines.
10. Achieve success in professional development through life-long learning.

Program outcomes (POs)

hh. an ability to apply knowledge of mathematics, science, and Mechanical Engineering

ii. an ability to design and conduct experiments, as well as to analyze and interpret data

jj. an ability to design a mechanical system, mechanical component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

kk. an ability to function on multidisciplinary teams

ll. an ability to identify, formulate, and solve mechanical engineering problems

mm. an understanding of professional and ethical responsibility

nn. an ability to communicate effectively

oo. the broad education necessary to understand the impact of mechanical engineering solutions in a global, economic, environmental, and societal context

pp. a recognition of the need for, and an ability to engage in life-long learning,

qq. a knowledge of contemporary issues

rr. an ability to use the techniques, skills, and modern mechanical engineering tools necessary for engineering practice.

Department of Mechanical engg													
Program: B.E (Mechanical Engineering)													
Course Title: MACHINE TOOLS AND OPERATIONS Course Code:15ME35B Theory: √ Practical:													
Prerequisites to this course: (Course title with course codes)			Manufacturing process		Production tech.		Machine shop		Mathematics				
Program Outcomes (POs)	a	b	c	d	e	f	g	h	I	j	k	L	m
	√	√			√	√	√	√			√		
Mapping of Course Outcomes with Pos	1,2,3,4,5	1,3,4			1,2,3,4,5	5	5	1			1,2,3,4,5		

Course category	Basic Sciences	General Humanities General/	Core						Elective
			G-A	G-B	G-C	G-D	G-E	G-F	

					√				
Teaching Methods:	PPT	OHP	Face to Face	Guest Lecture	Video lecture	Demo (Lab visit)	Seminars	Industrial Visits	
Units			1,2,3,4,5			1,2,5			
Continuous Assessment	Internal assessment tests				Assignments		Tutorial		
	03				03				
Contents beyond syllabus to meet POs:	Topics						POs attained		
	Visit to machine shop and Industry to demonstrate the processes.						a,b,c,e,g,h,k		
Approved by:	Module Coordinator			Dr.G.V.Patil					
	Program coordinator			Prof. S. B. Koulagi					

Achieving Intended Course Learning Outcomes

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

Sl.No.	Course Learning Outcomes	Possible capabilities, skills, expertise gained (codes)	Means of imparting the curriculum
1	CO1	Kn,Un	Class room lectures
2	CO2	Un, PSS	Class room lectures
3	CO3	PS, LS, Kn	Class room lectures
4	CO4	PS, LS,	Class room lectures
5	CO5	PS,AS	Class room lectures
6	CO6		
7	CO7		
8	C08		

Possible capabilities, skills, expertise gained	Code
Knowledge	Kn
Understanding (Comprehension)	Un
Problem solving skills (application skills)	PSS
Practical skills (application skills)	PS
Analytical skills	AS
Synthesis skills	SS
Written communication skills	WCS
Verbal/oral communication skills	VCS
Presentation skills	PS
Leadership skills	LS

COURSE PLAN

Semester: III **Year: 2017-18**

Subject: MACHINE TOOLS AND OPERATIONS	**Subject Code: 15ME35A**
Total No. of Lecture Hours: 50	**I A Marks : 20**
Exam Marks: 80	**Exam Hours: 03**
Lesson plan prepared by : Prof. C.R. Hiremath	**Date: 06/09/2016**

COURSE CONTENT

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

MODULE 2
MACHINING PROCESSES
Introduction, Types of motions in machining, turning and Boring, Shaping, Planing and Slotting, Thread cutting, Drilling and reaming, Milling, Broaching, Gear cutting and Grinding, Machining parameters and related quantities.**[Sketches pertaining to relative motions between tool and work piece only]** 10 Hours

MODULE 3

CUTTING TOOL MATERIALS, GEOMETRY AND SURFACE FINISH

Introduction, desirable Properties and Characteristics of cutting tool materials, cutting tool geometry, cutting fluids and its applications, surface finish, effect of machining parameters on surface finish.

Machining equations for cutting operations: Turning, Shaping, Planing, slab milling, cylindrical grinding and internal grinding, Numerical Problems 10 Hours

MODULE 4

MECHANICS OF MACHINING PROCESSES

Introduction, Chip formation, Orthogonal cutting, Merchants model for orthogonal cutting, Oblique cutting, Mechanics of turning process, Mechanics of drilling process, Mechanics of milling process, Numerical problems. 10 Hours

MODULE 5

TOOL WEAR, TOOL LIFE: Introduction, tool wear mechanism, tool wear equations, tool life equations, effect of process parameters on tool life, machinability, Numerical problems

ECONOMICS OF MACHNING PROCESSES: Introduction, choice of feed, choice of cutting speed, tool life for minimum cost and minimum production time, machining at maximum efficiency, Numerical problems 10 Hours

TEXT BOOKS:

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

2. All about Machine Tools, Heinrich Gerling, New Age International Publishers revised 2nd Edition, 2006

REFERENCE BOOKS:

1. Fundamental of Machining and Machine Tools, Geoffrey Boothroyd and Winston A. Knight, CRC Taylor &Francis, Third Edition.

2. Metal cutting principles, Milton C. Shaw, Oxford University Press, Second Edition, 2005.

Scheme of Examination:

Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

Prerequisites:

The student should have studied the course "Elements of Mechanical Engineering, Chemistry, Physics and Mathematics"

Overview of the Course:

The course content is planned to provide knowledge and skill required to become an efficient Engineer by keeping the lesions related to production field.

4. Basic understanding of various dimensions and functions of the production field as whole.
5. Analytical skill needed to tackle the ever-changing problems and situations modern competitive production.

6. To take appropriate decision for reasoning and supported by tools used in production process.

Course Outcomes (CO):

After a successful completion of the course, the student will be able to:

CO 1:

Explain the construction & specification of various machine tools.

CO 2:

Describe various machining processes pertaining to relative motions between tool & work piece.

CO 3:

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

CO 4:

Apply mechanics of machining process to evaluate machining time.

CO 5:

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

Relevance of the Course:

Production Engineers in general are involved in manufacturing of machine components that are designed by design engineers; they have to use their knowledge about different manufacturing processes such as turning, drilling, thread cutting, gear cutting and surface finishing operation and super finishing operations to find machining time, tools required, equipments needed and time needed, and to get dimensional accurate products with minimum wastages. Hence students have to study various machining process and techniques. Along with this they will learn about nontraditional machines and also super finishing operations, they have to get knowledge about CNC machine for automation production.

Application areas:

The basic course i.e. machine tool operations will be help full in manufacturing industries where production engineers are in charge of production units where they will come across different machine with different operations for manufacturing different components with high accuracy. . The students studying this course will find placements in various manufacturing industries and also the engineers who are interested in becoming entrepreneur in production line will get knowledge about the machines that they have to purchase and use for their particular product.

The real time applications are

1. Research department
2. Machine tool industries
3. Cutting tool industries
4. Machine shop
5. Workshop

Unit wise plan

Course Title / Code: MACHINE TOOLS AND OPERATIONS (15ME35B)	
Module No.: 1. MACHINE TOOLS	**Planned Hours: 10**

Learning Objectives:

At the end of the chapter the student should be able to:

1. Explain the construction and operation of lathe.
2. Identify the construction of drilling machine.
3. Compare shaping and planning machine.
4. Design driving mechanisms of lathe, shaping and planning machines
5. Demonstrate construction details of machine tools like, broaching, grinding machines.

Lesson Plan:

Lesson. No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter no.
L1	Introduction	Chalk and Board	k	1	T1/1, R2/4
L2	Classification	PPT		1	T1/1, R2/4
L3	Construction and specifications of lathe	Chalk and Board		1	T1/1, R2/4
L4	Drilling machine	Chalk and Board		1	T1/1, R2/4
L5	Milling machine	Chalk and Board		1	T1/1, R2/4
L6	Boring machine	Chalk and Board		1	T1/1, R2/4
L7	Broaching machine	Chalk and Board		1	T1/1, R2/4
L8	Shaping machine	Chalk and Board		1	T1/1, R2/4
L9	Planing machine	Chalk and Board		1	T1/1, R2/4
L10	Grinding machine	Chalk and Board		1	T1/1, R2/4

Assignment questions:	COs attained
1. Differentiate between a capstan, a turret and an engine lathe.	1
2. What are the specifications of machine tools ?	1
3. Explain turret and bar feed mechanism.	1
4. Explain shaper whit worth quick return mechanism and hydraulic mechanism.	1
5. Differentiate between shaping and planer machine.	1
6. With neat sketch explain broaching and grinding machine tools.	1

Unit wise plan

Course Title / Code: MACHINE TOOLS AND OPERATIONS (15ME35B)	
Module No.: 2. MACHINING PROCESSES	**Planned Hours: 10**

Learning Objectives:

At the end of the chapter the student should be able to:

1. Identify the types of motions in machining.
2. Demonstrate the various motions of turning , boring, shaping, planing and slotting,
3. Explain thread cutting, drilling and reaming, milling, broaching, gear cutting and grinding,
4. Explain machining parameters and related quantities.

Lesson Plan:

Lesson. No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter no.
L7	Introduction	Chalk and Board	c, k	2	T1/1, R2/4
L8	Types of motions in machining	PPT		2	T1/1, R2/4
L9	Machining motions in turning	Chalk and Board		2	T1/1, R2/4
L10	Machining motions in boring	PPT		2	T1/1, R2/4
L11	Machining motions in shaping	Chalk and Board		2	T1/1, R2/4
L12	Machining motions in planing	Chalk and Board		2	T1/1, R2/4
L13	Machining motions in slotting	Chalk and Board		2	T1/1, R2/4
L14	Machining motions in thread cutting	Chalk and Board		2	T1/1, R2/4
L15	Machining motions in drilling	Chalk and Board		2	T1/1, R2/4

L16	Machining motions in reaming,	Chalk and Board		2	T1/1, R2/4
L17	Machining motions in milling	Chalk and Board		2	T1/1, R2/4
L18	Machining motions in broaching	Chalk and Board		2	T1/1, R2/4
L19	Gear cutting and Grinding	Chalk and Board		2	T1/1, R2/4
L20	Machining parameters and related quantities	Chalk and Board		2	T1/1, R2/4

Assignment Questions	CO's attained
1. Identify the motions in machining.	2
2. Briefly explain machining motions related to turning, boring, shaping and planing?	2
3. Briefly explain the thread cutting operations.	2
4. Explain the various machining parameters related to respective machining operations.	2

Unit wise plan

Course Title / Code: MACHINE TOOLS AND OPERATIONS (15ME35B)	
Module No.: 3. CUTTING TOOL MATERIALS, GEOMETRY AND SURFACE FINISH	**Planned Hours: 10**

Learning Objectives:

At the end of the chapter the student should be able to:

1. Identify desirable properties of cutting tool materials and cutting fluids.
2. Access cutting tool geometry.
3. Analyze surface finish and parameters affecting surface finish.

Lesson Plan:

Lesson. No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter no.
L21	Introduction, desirable properties of cutting tool materials.	PPT	h, k	3	T1/2, R1/23
L22	Characteristics of cutting tool materials.	PPT		3	T1/2 , R1/23
L23	Cutting tool geometry.	Chalk and Board		3	T1/2, R1/11
L24	Cutting fluids and its applications.	Chalk and Board		3	T1/2, R1/11
L25	Surface finish.	Chalk and Board		3	T1/9
L26	Effect of machining parameters on surface finish.	Chalk and Board		3	T1/9
L27	Machining equations for cutting operations: Turning, Shaping	Chalk and Board		3	T1/1,2
L28	Machining equations for cutting operations: Planing, slab milling	Chalk and Board		3	T1/1,2
L29	Machining equations for cutting operations: cylindrical grinding and internal	Chalk and Board		3	T1/1,2

	grinding				
L30	Numerical Problems	Chalk and Board		3	T1/1,2

Assignment questions:	**COs attained**
1. What are the important properties of cutting tool material explain them.	3
2. Explain different cutting tool materials with their applications.	3
3. Explain different types of cutting fluids.	3
4. How you are selecting cutting fluids?	3
5. Explain machining equations in metal cutting	3

Unit wise plan

Course Title / Code: MACHINE TOOLS AND OPERATIONS (15ME35B)	
Module No.: 4. MECHANICS OF MACHINING PROCESSES	**Planned Hours: 10**

Learning Objectives:

At the end of the Unit, the student should be able to;

1. Analyze single point cutting tool and design of Merchants circle diagram,
2. Establish the shear angle and cutting ratio relation.
3. Analyze mechanics of turning drilling and milling processes.

Lesson Plan:

Lesson. No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter no.
L31	Introduction.	PPT	j, k	4	T1/3
L32	Chip formation.	PPT		4	T1/3
L33	Types of chips.	PPT		4	T1/3
L34	Orthogonal and Oblique cutting.	Chalk and Board		4	T1/3,R1/4
L35	Merchants model for orthogonal cutting.	Chalk and Board		4	T1/3,R1/4
L36	Merchants model for orthogonal cutting.	Chalk and Board		4	T1/3,R1/4
L37	Mechanics of turning process.	Chalk and Board		4	T1/3
L38	Mechanics of drilling process.	Chalk and Board		4	T1/3
L39	Mechanics of milling process	Chalk and Board		4	T1/3
L40	Numerical problems	Chalk and Board		4	T1/3

Assignment questions:	COs attained
1. Explain nomenclature and its geometry of single point cutting tool.	4
2. Write a short note on orthogonal and oblique cutting tool.	4
3. Explain different types of chips and their causes.	4
4. Derive the relation between frictional force and normal force on cutting tool.	4

5. Derive the expression $\square = \square/2 - \frac{\square}{2} + \square/2$	4
6. The following data were obtained during orthogonal cutting of a certain material.: Chip thickness =0.45mm, Width of cut =2.5mm, Feed = 0.25 mm/rev, Cutting force = 115 kg, Thrust force =29.5 kg, Cutting speed was 150 m/min The rake angle was +10º, Calculate the following. a) Chip thickness ratio b) Shear angle b) Velocity of the chip along the tool face b) Frictional force along the tool face. d) Frictional force along the tool face e) Shear stress f) Power required for cutting	4

Unit wise plan

Course Title / Code: MACHINE TOOLS AND OPERATIONS (15ME35B)	
Module No.: 5. MECHANICS OF MACHINING PROCESSES	**Planned Hours: 10**

Learning Objectives:

At the end of the Unit, the student should be able to;

1. Analyze tool life and effect of cutting parameters on tool life.
2. Assess Taylor's tool life.
3. Analyze economics of machining.
4. Finding maximum efficiency at minimum cost.

Lesson Plan:

Lesson. No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter no.
L41	Introduction, tool wear mechanism.	Chalk and Board	b, e, k	5	T1/5, R1/4
L42	Forms of wear.	Chalk and Board		5	T1/5, R1/4
L43	Flank wear curve.	Chalk and Board		5	T1/5, R1/4
L44	Tool failure criteria.	Chalk and Board		5	T1/5, R1/4
L45	Tool wear equations.	Chalk and Board		5	T1/5, R1/4
L46	Tool life equations.	Chalk and Board		5	T1/5, R1/4
L47	Effect of process Parameters on tool life.	Chalk and Board		5	T1/5, R1/4
L48	Machinability.	Chalk and Board		5	T1/5, R1/4
L49	Factors affecting machinability	Chalk and Board		5	T1/5, R1/4
L50	Numerical problems.	Chalk and Board		5	T1/5, R1/4

Assignment Questions	COs attained
11. Explain different tool wear mechanisms.	5
12. Explain the regions of flank wear curve.	5
13. List the parameters affecting the tool life.	5
14. Illustrate machinability with examples.	5

15. A mild steel bar is turned on a lathe with a cutting tool having rake angle 10º and cutting speed of 200 mpm. If the width of cut is 3 mm and uncut thickness is 0.3 mm determine. a) The shear angle. b) Cutting force and thrust force c) Machining constant for the mild steel work piece. The maximum shear stress is 400N/mm²and Co-efficient of the friction is 0.5	5

Syllabus for the internal Assessment Tests (Tentative):

Test	Units/Modules	COs attained
Internal Assessment Test-I	Module - 1, Module - 2	1, 2,
Internal Assessment Test-II	Module - 3, Module - 4	3,4
Internal Assessment Test-III	Module - 5	5
Test pattern: Three questions will be given and students have to answer any two full questions. Each question carries 10 marks.		

Evaluation Scheme:

Assessment	Marks
Internal Assessment tests	20
VTU Semester examination	80
Total	100

…End of Machine tools and operations Lesson Plan…

CAMD (15ME35)

[As per Choice Based Credit System (CBCS) scheme]

2016 - 2017

Department of Mechanical Engineering													
Program: B.E.													
Course Title: Computer Aided Machine Drawing Course Code: 15ME35 Theory: ✓ Practical:													
Prerequisites to this course: (Course title with course codes)			CAED 14CED14										
Program Outcomes (POs)	a	b	c	d	e	f	g	h	i	j	k	l	m
	✓ x	✓ x	✓		✓ x				✓ x		✓ x		
Mapping of Course Outcomes with POs	1,2,3,4	1,4	1,2,3,4		1,2,3,4				1,2,3,4		1,2,3,4		

Course category	Basic Sciences	General Humanities	Core						Elective
			G-A	G-B	G-C	G-D	G-E	G-F	
			✓						

Teaching Methods:	PPT	OHP	Face to face	Guest Lecture	Video lecture	Demo (Lab visit)	Seminars	Industrial visits
Units			I-V			I-V		

Continuous Assessment	Internal assessment tests	Assignment	Tutorial
	1	1	

Contents beyond	Topics	POs attained

syllabus to meet POs:		
Approved by:	Module Coordinator	Prof.S.S.Chappar
	Program coordinator	Prof.V.V.Hokrani

Achieving Intended Course Learning Outcomes

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

Sl.No.	Course Learning Outcomes	Possible capabilities, skills, expertise gained (codes)	Means of imparting the curriculum
1	CO1	Kn, Un, AS	Class room lectures, Lab visit
2	CO2	Kn, Un, PSS	Class room lectures, Lab visit
3	CO3	Kn, Un, PSS,PS	Class room lectures, Lab visit
4	CO4	Kn, Un, PS,AS	Class room lectures, Lab visit

Possible capabilities, skills, expertise gained	**Code**
Knowledge	Kn
Understanding (Comprehension)	Un
Problem solving skills (application skills)	PSS
Practical skills (application skills)	PS
Analytical skills	AS
Synthesis skills	SS
Written communication skills	WCS
Verbal/oral communication skills	VCS
Presentation skills	PS
Leadership skills	LS

Program Educational Objectives (PEOs)

The educational objectives of the Mechanical Engineering Program are to prepare our graduates to:

11. Establish a successful career in Mechanical Engineering or related fields in Industry and other organizations where an engineering approach to problem solving is highly valued.
12. Develop the ability among the students to synthesize the data and technical concepts for applications to the product design.
13. Contribute significantly in a multidisciplinary work environment with high ethical standards and with understanding of the role of engineering in economy and the environment.
14. Excel in graduate study and research, reaching advanced degrees in engineering and related disciplines.
15. Achieve success in professional development through life-long learning.

Program outcomes (POs)

ss. an ability to apply knowledge of mathematics, science, and Mechanical Engineering

tt. an ability to design and conduct experiments, as well as to analyze and interpret data

uu. an ability to design a mechanical system, mechanical component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

vv. an ability to function on multidisciplinary teams

ww. an ability to identify, formulate, and solve mechanical engineering problems

xx. an understanding of professional and ethical responsibility

yy. an ability to communicate effectively

zz. the broad education necessary to understand the impact of mechanical engineering solutions in a global, economic, environmental, and societal context

aaa. a recognition of the need for, and an ability to engage in life-long learning,

bbb. a knowledge of contemporary issues

ccc. an ability to use the techniques, skills, and modern mechanical engineering tools necessary for engineering practice.

COURSE PLAN

Semester: III

Course Title: Computer Aided Machine Drawing	**Course Code: 10ME35**
Total Contact Hours: 50	**Duration of Exam: 03 Hrs**
Total Exam Marks: 80	**Total I.A. Marks: 20**
Number of Lecture Hours/Week: 06 **(2 hrs. Theory and 4 hrs Practical)**	**Credits – 04**
Lesson Plan Prepared by: Prof. V. V. Hokrani	**Date: 01/06/2017**

Course objectives:

- Know and comprehend the standards of machine drawing practiced by Bureau of Indian standards (B.I.S.).
- Understand general projection theory, with an emphasis on the use of orthographic projection to represent three-dimensional objects in Two-dimensional views Knowledge on Assemble of machine elements in mechanical engineering applications.
- Knowledge of modern engineering software tools for mechanical engineering design and analysis.

COURSE CONTENT

Modules	Teaching Hours
Introduction: Review of graphic interface of the software. Review of basic sketching commands and navigational commands. Starting a new drawing sheet. Sheet sizes. Naming a drawing. Drawing units, grid and snap.	02 Hours

Module – 1: **Sections of Solids:** Sections of Pyramids, Prisms, Cubes, Tetrahedrons, Cones and Cylinders resting only on their bases (No problems on, axis inclinations, spheres and hollow solids). True shape of sections. **Orthographic views:** Conversion of pictorial views into orthographic	06 Hours

projections of simple machine parts with or without section. (Bureau of Indian Standards conventions are to be followed for the drawings) Hidden line conventions. Precedence of lines.	
Module – 2: **Thread forms:** Thread terminology, sectional views of threads. ISO Metric (Internal & External) BSW (Internal & External) square and Acme. Sellers thread, American Standard thread. **Fasteners:** Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly) simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, counter sunk head screw, grub screw, Allen screw.	08 Hours

Module – 3: **Keys & Joints:** Parallel key, Taper key, Feather key, Gibhead key and Woodruff key **Riveted Joints:** single and double riveted lap joints, butt joints with single/double cover straps (Chain and Zigzag, using snap head rivets). Cotter joint (socket and spigot), knuckle joint (pin joint) for two rods.	08 Hours
Module – 4: **Couplings:** Split Muff coupling, Protected type flanged coupling, Pin (bush) type flexible coupling, Oldham's coupling and Universal coupling (Hooks' Joint)	08 Hours

Module – 5: Assembly Drawings (Part drawings should be given) 1. Plummer block (Pedestal Bearing) 2. Rams bottom safety valve 3. I.C. Engine connecting rod 4. Screw jack (Bottle type) 5. Tailstock of lathe 6. Machine vice 7. Tool Head of a shaper	18 Hours

Text books:

1. 'Machine Drawing', K.R. Gopala Krishna, Subhash Publication.
2. A Text Book of Computer Aided Machine Drawing', S. Trymbaka Murthy, CBS Publishers, New Delhi, 2007.

Reference Books:

1. Machine Drawing', N.D.Bhat & V.M.Panchal.

Prerequisites:

The student should have undergone the course of "Computer Aided Engineering Drawing" and B.I.S. conventions.

Course Description:

Overview of the course:

Machine drawing is a universal language of engineers to convey effectively the various aspects and details of an object to be produced. The course deals with the sections of solids, conversions of pictorial to orthographic projections of simple machine parts with sectional views, views of riveted joints, couplings, threads and fasteners. The course also deals with the practicing of assembly sketches and drawings of screw jack, plummer block, tail stock of lathe etc. It displays a precise picture of the object or machine part to be produced and conveys the same object to every trained eye. It also gives importance of limits and fits and their use on drawings. All drawings will be drawn using SOLID EDGE software. The course gives hands on experience to the students to develop 3D models and their sectional views.

Relevance of the course:

Machine drawing is a base for almost all manufacturing activities. Before going to start the production process, engineers should have detailed sketch and drawings. It helps to understand the machines, their parts and materials. At the same time, it lays the foundation for the know-how about their design. Acquiring expertise in 'machine drawing' means growing as a good 'machine designer'.

Application areas:

The various products used by human being like Automotive, Electronic and Electrical are manufactured based on the drawings. The main part of the design engineer is to work-out proper design and drawings. Graduates from our program may find positions as a design engineer in many production fields in different countries.

Course Outcomes (COs):

After learning CAMD course, the students will be able to:

1. Students will be able to understand the steps in producing drawings according to bureau of Indian standards (B.I.S.).

2. Students will be able to understand and create drawings of machine parts and their assemblies.

3. Students can work effectively with engineering and science teams as well as with multidisciplinary designs.

4. Students will be able to skillfully use modern engineering software tools for mechanical engineering design and analysis.

Module wise plan

Course Title /Code: Computer Aided Machine Drawing (15ME35)	
Introduction:	**Planned Hours: 02**

Learning Objectives:

At the end of the chapter student should be able to

1. Use the Solid Edge software for drawing.

Lesson Schedule:

Lesson No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter No.
L1	Introduction, Review of Graphics interface of software, Review of basic sketching commands,	Demo	a, e, i	1,2,3,4	R1/2
L2	Starting a new drawing sheet. Sheet sizes. Naming a drawing. Drawing units, grid and snap.	Demo		1,2,3,4	R1/2

Module wise plan

Course Title /Code: Computer Aided Machine Drawing (15ME35)	
Module – 1: Sections of Solids, Orthographic Views	**Planned Hours: 06**

Learning Objectives:

At the end of the chapter student should be able to

1. Sketch the solutions of the sections of solids.
2. Show the location of cutting plane by chain line thickened at the ends and thin elsewhere
3. Draw the sectional views of simple solids such as prism, pyramid, cylinder, cone in simple positions using BIS conventions.
4. Draw the true shape of section.
5. Find the inclination of the cutting plane when true shape of section of an object is given.
6. Sketch and draw the orthographic views of simple machine parts (top view, front view, side view) using first angle projection.
7. Sketch and draw the sectional views of simple machine parts.

Lesson Schedule:

Lesson No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter No.
L3	Sections of pyramids, prisms, cubes, tetrahedrons, cones and cylinders, True shape of section	Chalk and Board	a,b,c,e,i,k	1	T1/1
L4	Conversion of pictorial views of machines parts to orthographic projections with full section & without section.	Chalk and Board		1	R1/4, R1/5

- **04 hours practice on software**

Assignment Questions	COs Attained
1. A square prism of base 30 mm side stands vertically on HP. It is cut by section plane in such a way that true shape of cuts surface is a hexagon is having two opposite parallel sides 30 mm long and remaining four sides 40	**1**

mm long. Determine height of the prism and inclination of the section plane. Draw the front view, sectional top view and true shape of section.	
2. A vertical cylinder of 50 mm diameter is cut by an AVP making 30 degree to VP in such a way that true shape of section is rectangle is 40 mm and 80 mm sides. Draw the projections and the true shape of section.	**1**
3. A cube of 40 mm long edges rests with one of its faces on H.P. such that one of its vertical faces is inclined at 30 degree to V.P. A section plane perpendicular to HP and inclined at 60 degree to passes through the cube such that a square face making 30 0 with V.P. is cut into two halves. Draw the sectional front view and the true shape of section.	**1**
4. A pentagonal pyramid base 25 mm side and axis 75 mm long is placed with its base on HP such that two of base edges make equal inclination with VP and near to it. It is cut by two-section plane, both perpendiculars to VP. One of the section planes is horizontal and is 40 mm from the apex and the other section plane makes an angle of 45 degrees with HP also intersects axis at the same points. Draw the sectional top view and show both the true shape of sections lying adjoining with each other.	**1**
5. A cone base 60 mm diameter and axis 70 mm stands vertically with its base on HP. A section plane perpendicular to VP and parallel to one of the end generators of the cone passes at a distance of 15 mm from it. Draw the sectional top view and true shape of the section.	**1**
6. A vertical cylinder of 50 mm diameter and 75 mm long is completely penetrated by a horizontally cylinder of 40 mm diameter 75 mm long such that their axes bisect each other at right angles. The axes of both the cylinders are parallel to VP. Draw the intersection curve.	**1**
7. Draw the following views for the objects shown in figure 1-18 i) front view ii) top view iii) right side view	**1**

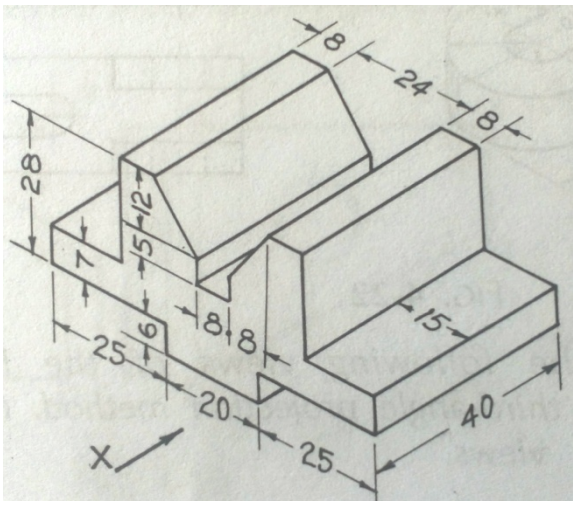

Figure 1

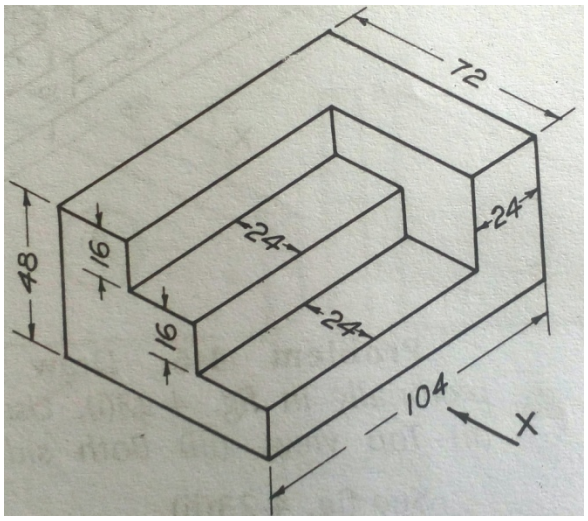

Figure 2

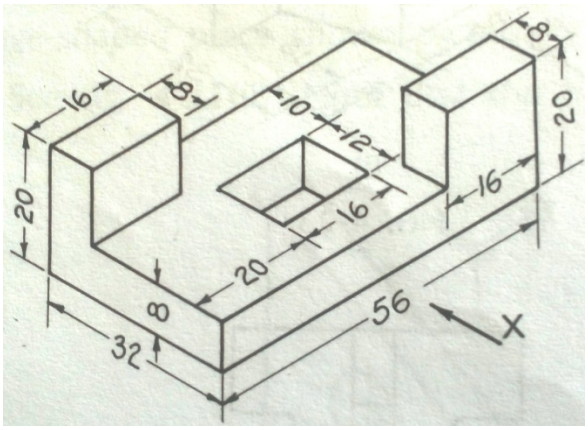

Figure 3

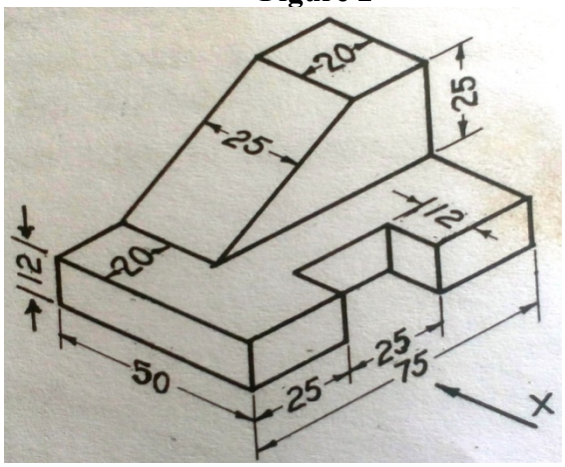

Figure 4

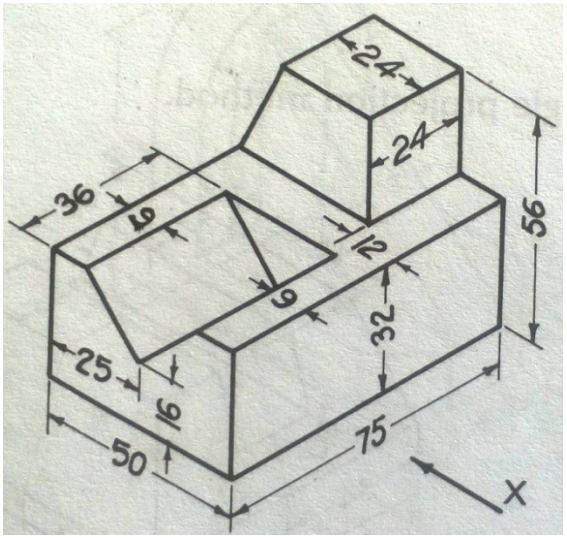

Figure 5

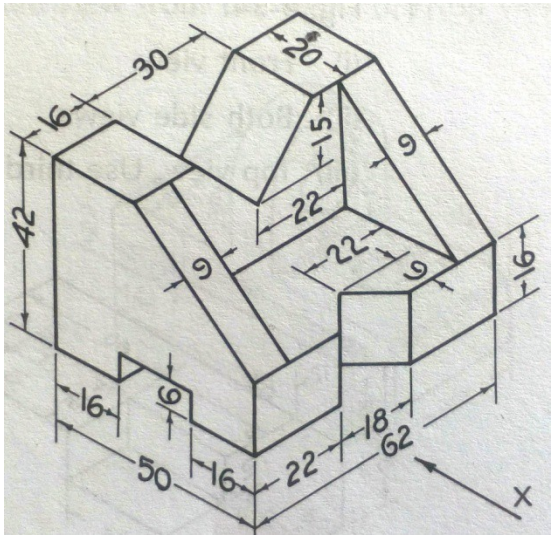

Figure 6

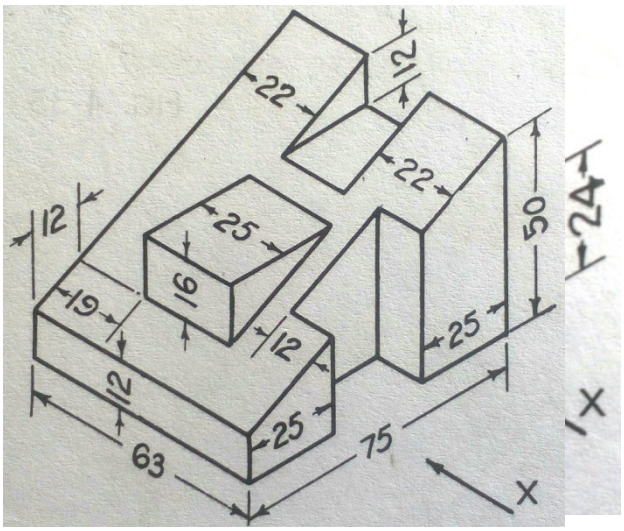

Figure 7

Figure 8

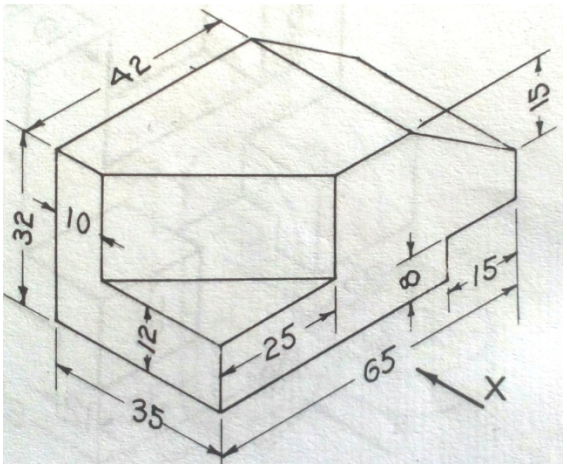

Figure 9

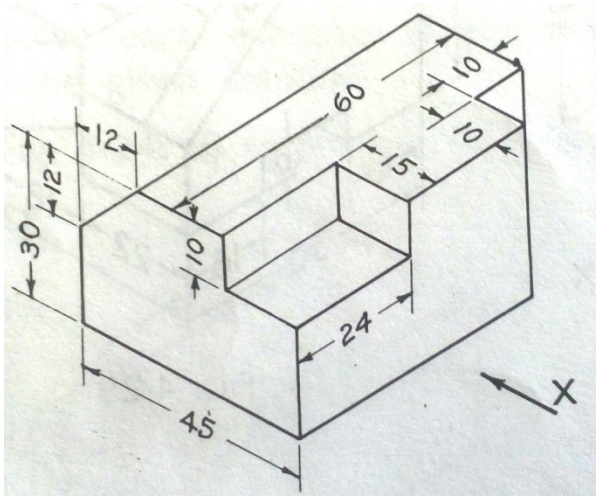

Figure 10

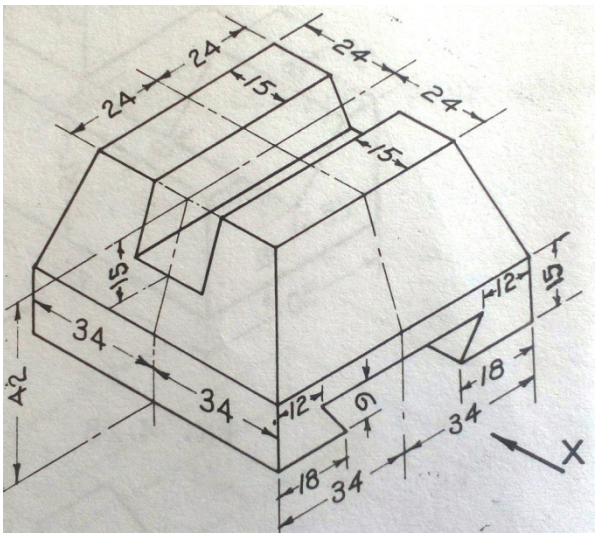

Figure 11

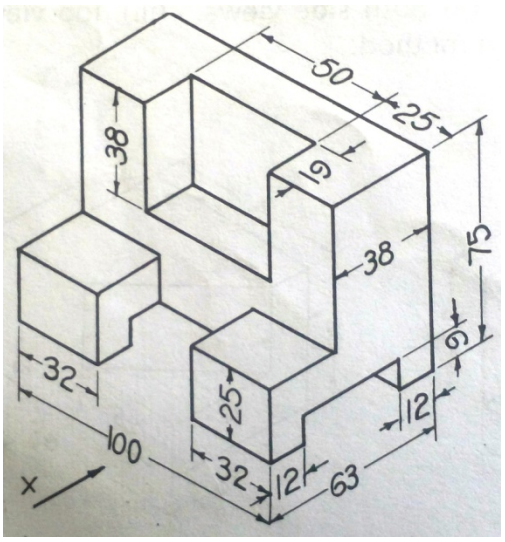

Figure 12

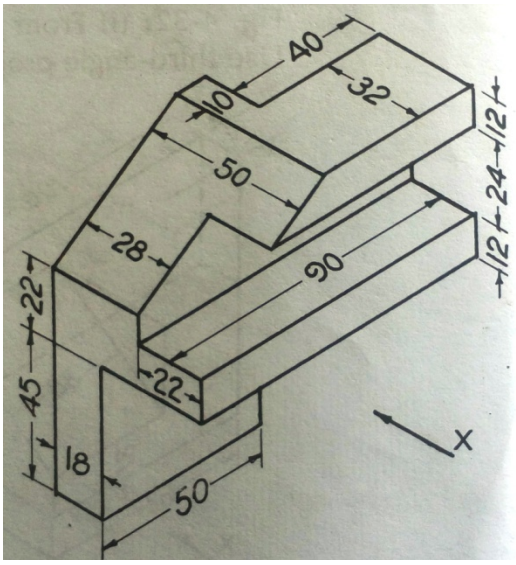

Figure 13

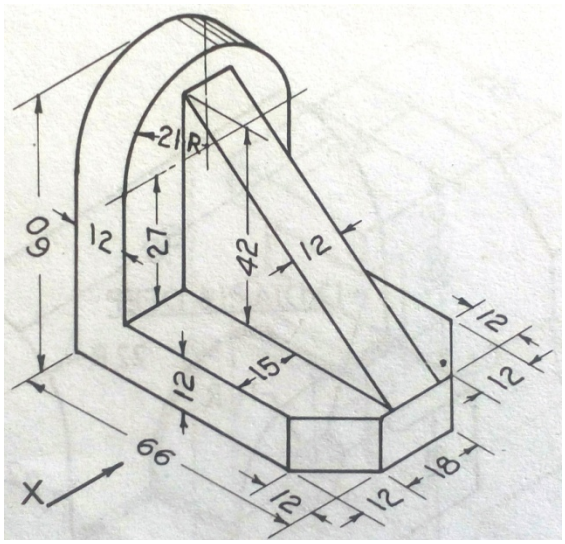

Figure 14

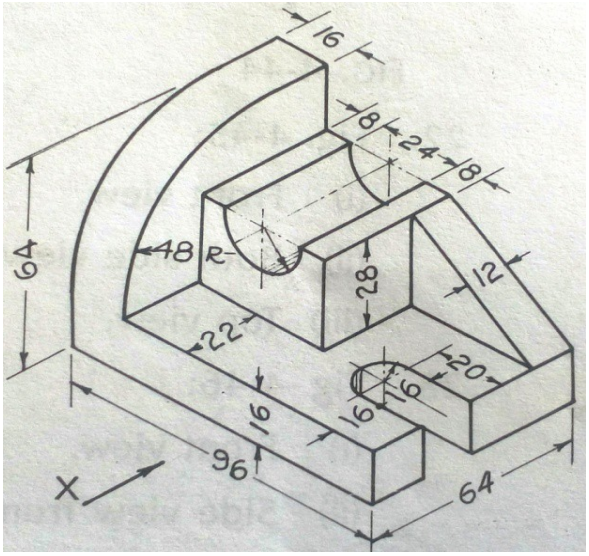

Figure 15

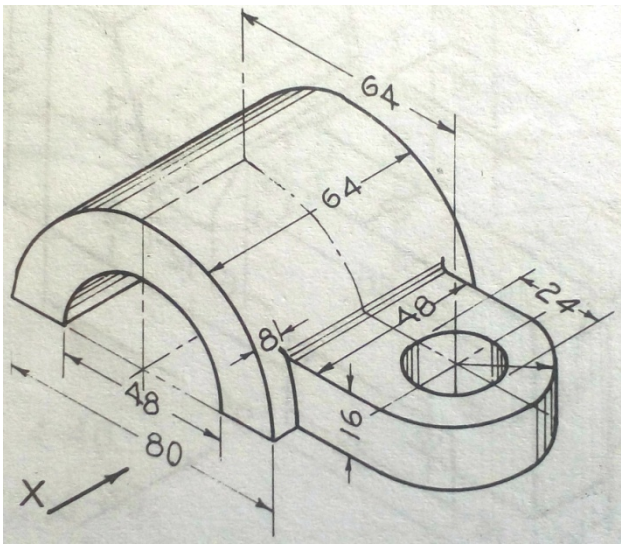

Figure 16

Chapter wise plan

Course Title /Code: Computer Aided Machine Drawing (15ME35)	
Module – 2: Threads Forms, Fasteners	**Planned Hours: 08**

Learning Objectives:

At the end of the chapter student should be able to

1. Sketch and draw ISO metric threads.
2. Sketch & draw square, ACME & BSW forms of threads using conventional representation.
3. Explain the application of fasteners
4. Sketch and draw the hexagonal and square headed bolt, nut and washer assembly
5. Sketch and draw the taper pin, split pin assembly, counter head screw, grub screw and allen screw.

Lesson Schedule:

Lesson No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter No.
L5	Thread terminology, Sectional views of threads, ISO Metric and BSW (internal and external screw thread forms). Square and Acme thread forms, Sellers thread, American standard thread.	Chalk and Board	a,c,e,i,k	2	R1/7
L6	Hexagonal & Square headed bolt and nut with washer, headed bolt and nut with washer, Simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, Countersunk head screw, grub screw, Allen screw.	Chalk and Board		2	R1/8

- **06 hours practice on software**

Assignment Questions	COs

	Attained
1. Draw the sketches to indicate conventional representation of following a) A coarse ISO metric thread profile for M24. Also indicate pitch of 3 mm on it.	**2**
2. Draw the sketches indicating the conventional representation of the following: square, ACME & BSW thread profile indicate pitch of 15 mm on it.	**2**
3. Show various parts (nomenclature) of screw thread.	**2**
4. Name the threads series (two) recommended by ISO.	**2**
5. What are right hand, left hand, single start, multi-start threads?	**2**
6. Name different forms of V – threads.	**2**
7. Draw the sketches to indicate conventional representation of following: Grub screw of M6 with dog point.	**2**
8. Draw the dimensioned sketches of the following: stud bolt, flanged nut, slotted and wing nut	**2**
9. Draw the dimensioned sketches of the following counter sunk head, grub and allen screw	**2**
10. Draw the three views of ISO threaded hexagonal bolt 120 mm long 24 mm diameter and a thread length of 50 mm with a hexagonal nut. Indicate all the proportions dimensions.	**2**
11. Draw the three views of ISO threaded square bolt 120 mm long 24 mm diameter and a thread length of 50 mm with a square nut. Indicate all the proportions dimensions.	**2**

Module wise plan

Course Title /Code: Computer Aided Machine Drawing (15ME35)	
Module – 3: Keys and Joints	**Planned Hours: 08**

Learning Objectives:

At the end of the chapter student should be able to

1. Distinguish between temporary and permanent joints
2. Sketch and draw the different types of keys.
3. Explain the significance and application of riveted joints
4. Sketch and draw single and double riveted lap joint
5. Sketch and draw butt joint single strap with chain and zigzag arrangement
6. Sketch and draw two views of socket and spigot cotter joint
7. Sketch and draw two views of knuckle joint

Lesson Schedule:

Lesson No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter No.
L7	Keys-Parallel, Feather, Gib head and Woodruff, Socket and spigot cotter joint, Knuckle joint for two rods.	Chalk and Board	a,c,e,i,k	3	R1/9
L8	Riveted joints, single and double riveted lap joint, Butt joint single strap and double strap with chain arrangement & zigzag arrangement.	Chalk and Board		3	R1/12

- **06 hours practice on software**

Assignment Questions	COs Attained
1. Draw to 1:2 scale, the top view and sectional front view of a single riveted lap joint. The thickness of plates is 20 mm. Show at least three rivets. Indicate all the dimensions. Use snap head rivets.	**3**
2. Draw 1:2 scale, the top view and sectional front view of a double riveted lap joint with I) chain ii) zigzag riveting. The thickness of plates is 25 mm. Show al least three rivets in each row. Indicate all the dimensions. Use snap head for rivets.	**3**
3. Draw to 1:2 scale the top view and sectional front view of a single riveted butt joint with I) single cover and ii) double cover plates. The thickness of	**3**

	plates is 20 mm. Show at least three rivets. Indicate all dimensions. Use snap head rivets.	
4.	Draw to 1:2 scale, the top view and sectional front view of double riveted butt joint with double cover plates with chain riveting. The thickness of the plates is 10 mm. Show al least three rivets in each row. Indicate all dimensions. Use snap head rivets.	**3**
5.	Sketch neat and proportionate figure of a socket and spigot cotter joint showing sectional front view and side view from the socket end. Take diameter of rods to be 20 mm	**3**
6.	Draw a neat sketch of a double riveted butt joint with single strap. The rivets are to be in a zig-zag fashion. Assume and indicate the dimensions and show the calculations.	**3**
7.	Draw the following types of rivet heads of diameter 22 mm. Indicate the proportions of rivet head in terms of the diameter of the rivet along with the actual dimensions. i)snap head ii) pan head iii) conical iv) countersunk v) rounded countersunk vi) ellipsoid vii) mushroom head viii) steeple head ix) flat head.	**3**
8.	Draw the sectional front view & top view of a double riveted lap joint with zig-zag riveting to connect two plates of 12mm thickness.	**3**

Module wise plan

Course Title /Code: Computer Aided Machine Drawing (15ME35)	
Module – 4: Couplings	**Planned Hours: 08**

Learning Objectives:

At the end of the chapter student should be able to

Sketch and draw Split muff coupling and protected type of flange coupling.

1. Sketch and draw two views of pin type of flexible coupling.
2. Sketch and draw two views of universal coupling and Oldham's coupling

Lesson Schedule:

Lesson No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter No.
L9	Split muff coupling, Protected type flanged coupling, Pin (bush) type flexible coupling	Chalk and Board	a,c,e,i,k	3	T2/14
L10	Oldham's coupling, Universal coupling (Hook's joint).	Chalk and Board		3	T2/14

- **06 hours practice on software**

Assignment Questions	COs Attained
1. Sketch half sectional front view of a protected type of flange coupling to connect shafts of 20 mm diameter. Indicate all proportions with dimensioning prepare list	**3**
2. Sketch assembly of universal coupling and sketch following views a) front view with top half in section b) top view c) right view with left half in section	**3**
3. Sketch the following views of a bushed pin type flexible coupling to connect two shafts of 20 mm diameter a) front view with top half in section b) side view from the pin end.	**3**

Module wise plan

Course Title /Code: Computer Aided Machine Drawing (15ME35)	
Module – 5: Assembly Drawings	**Planned Hours: 18**

Learning Objectives:

At the end of the chapter student should be able to

1. Identify the purpose, principle and field of applications of the machine to be assembled
2. Decide mating dimensions between two components which are to be assembled
3. Prepare free hand sketch of main view or important view (usually elevation) and add additional views to it.
4. Select suitable scale for entire assembly drawing fitting in the available sheet
5. Draw required orthographic views (elevation, plan and profile views)
6. Prepare bill of materials containing item no, drawing no., description (name of the component), material and number of each of the components
7. Label each components by a leader line and numbering it
8. Draw the assembly drawing with sectional views using Solid Edge software.
   - Plummer block (Pedestal bearing)
   - Rams bottom safety valve
   - I.C. Engine connecting rod
   - Screw jack (Bottle type)
   - Tail stock of lathe
   - Machine vice
   - Tool head of shaper

Lesson Schedule:

Lesson No.	Topics covered	Teaching Method	POs Attained	COs Attained	Reference book/Chapter No.
L11	Plummer block (Pedestal bearing) & Rams bottom safety valve	Chalk and Board	a,b,c,i,k	4	T2/19
L12	I.C. Engine connecting rod & Screw jack (Bottle type)	Chalk and Board		4	T2/20

L13	Tail stock of lathe	Chalk and Board		4	T2/20
L14	Machine vice & Tool head of shaper	Chalk and Board		4	T2/18

- **14 hours practice on software**

Assignment Questions	COs Attained
1. Assemble the parts of the screw jack and draw the following views of the assembly when the top face of the load-bearing cup is raised to a height of 350 mm above the bearing surface of the body a) front view in half section b) top view. Show only the important dimensions on the assembly drawing. Write the title – Screw jack. Add the item list	**4**
2. Assemble the parts of tailstock of a lathe and draw the following views of the assembly i) front view in section ii) top view iii) end view looking from the dead centre end.	**4**
3. Draw the following assembled views of the Petrol engine connecting rod with its axis horizontal to 2:1 scale a) front view with top half in section b) top view with front half in section c) side view with bottom half in section looking from the big end	**4**
4. Assemble the parts of tool head of shaping machine and draw the following views of the assembly I) front view ii) top view iii) side view in section. Choose scale 1:2	**4**
5. Draw the following views of the assembled Machine vice to 1:1 scale with the jaws spread 50 mm apart a) front view in section b) top view c) left view showing the movable jaw in half section	**4**
6. Assemble the parts of petrol engine piston and draw the following views of the assembly i) front view in section ii) top view showing one half in section iii) end view take 2:1 scale	**4**
7. Assemble the parts of Rams bottom safety valve and draw the following views of the assembly i) front view with right half in section ii) top view iii) right side view.	**4**

Mechanical Measurements Metrology (15 ME 36 B)

2017-18

Program Educational Objectives (PEOs)

The educational objectives of the Mechanical Engineering Program are to prepare our graduates to:

16. Establish a successful career in Mechanical Engineering or related fields in Industry and other organizations where an engineering approach to problem solving is highly valued.
17. Develop the ability among the students to synthesize the data and technical concepts for applications to the product design.
18. Contribute significantly in a multidisciplinary work environment with high ethical standards and with understanding of the role of engineering in economy and the environment.
19. Excel in graduate study and research, reaching advanced degrees in engineering and related disciplines.
20. Achieve success in professional development through life-long learning.

Program outcomes (POs)

ddd. an ability to apply knowledge of mathematics, science, and Mechanical Engineering

eee. an ability to design and conduct experiments, as well as to analyze and interpret data

fff. an ability to design a mechanical system, mechanical component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

ggg. an ability to function on multidisciplinary teams

hhh. an ability to identify, formulate, and solve mechanical engineering problems

iii. an understanding of professional and ethical responsibility

jjj. an ability to communicate effectively

kkk. the broad education necessary to understand the impact of mechanical engineering solutions in a global, economic, environmental, and societal context

lll. a recognition of the need for, and an ability to engage in life-long learning,

mmm. a knowledge of contemporary issues

nnn. an ability to use the techniques, skills, and modern mechanical engineering tools necessary for engineering practice.

Department of: Mechanical Engineering	
Program: Mechanical Engineering (Regular)	
Course Title: Mechanical Measurements and Metrology	Course Code: 10ME32B/42B
Theory: ✓	Practical: ☐

Prerequisites to this course: (Course title with course codes)	MATHEMATICS, PHYSICS												
Program Outcomes (POs)	a	b	c	d	e	f	g	h	i	j	k		
Mapping of Course Outcomes with POs													

Course category	Basic Sciences	General Humanities General/	Core						Elective
			G-A (D)	G-B (T)	G-C (P)	G-D (M)			
					√				

Teaching Methods:	PPT	OHP	Face to face	Guest Lecture	Video lecture	Demo (Lab visit)	Seminars	Industrial visits
Units			I, II, III,IV,V, VI,VII,VIII					

Continuous Assessment	Internal assessment tests	Assignment	Tutorial
	✓	✓	

Contents beyond syllabus to meet POs:	Topics	POs attained

Approved by:	Module Coordinator	Prof. G.V.Patil
	Program coordinator	Prof S. B. Koulagi

Achieving Intended Course Learning Outcomes

The following skills are directly or indirectly imparted to the students in the following teaching and learning methods:

Sl.No.	Course Learning Outcomes	Possible capabilities, skills, expertise gained (codes)	Means of imparting the curriculum
1	CO1	Kn	Class room lectures
2	CO2	Kn,Un	Class room lectures
3	CO3	PS, AS	Class room lectures
4	CO4	Kn	Class room lectures
5	CO5	AS	Class room lectures
6	CO6	AS	Class room lectures

Possible capabilities, skills, expertise gained	**Code**
Knowledge	Kn
Understanding (Comprehension)	Un
Problem solving skills (application skills)	PSS
Practical skills (application skills)	PS
Analytical skills	AS
Synthesis skills	SS
Written communication skills	WCS
Verbal/oral communication skills	VCS
Presentation skills	PS
Leadership skills	LS

COURSE PLAN

Semester: III **Year: 2017-18**

Subject: Mechanical Measurements & Metrology	**Subject code: 15 ME 36 B**
Total Teaching Hours: 50	**I A Marks:20**

Exam Marks: 80	**Exam Hours: 03**
Lesson Plan Prepared by: Prof S.V. Hiremath	**Date:05/08/2016**

Course Content

MODULE - 1: **Introduction to Metrology:** Definition, objectives and concept of metrology, Need of inspection, Principles, process, methods of measurement, Classification and selection of measuring instruments and systems. Accuracy, precision and errors in measurement. System of measurement, Material Standard, Wavelength Standards, Subdivision of standards, Line and End standards, Classification of standards and Traceability, calibration of End bars(Numericals), standardization. **Linear Measurement and angular measurements:** Slip gauges- Indian standards on slip gauge, method of selection of slip gauge, stack of slip gauge, adjustable slip gauge, wringing of slip gauge, care of slip gauge, slip gauge accessories, problems on building of slip gauges (M87, M112). Measurement of angles- sine bar, sine center, angle gauges, optical instruments for angular measurements, Auto collimator-applications for measuring straightness and squareness.	**10 Hrs**
MODULE - 2: **System of Limits, Fits, Tolerance and Gauging:** Definition of tolerance, Specification in assembly, Principle of interchangeability and selective assembly, limits of size, Indian standards, concept of limits of size and tolerances, definition of fits, hole basis system, shaft basis system, types of fits and their designation (IS 919-1963), geometric tolerance, position-tolerances. Classification of gauges, brief concept of design of gauges (Taylor's principles), Wear allowance on gauges, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials. **Comparators:** Functional requirements, classification, mechanical- Johnson Mikrokator, sigma comparators, dial indicator, electricalprinciples, , LVDT, Pneumatic- back pressure gauges, solex comparators and optical comparators- Zeiss ultra-optimeter.	**10 Hrs**
MODULE - 3: **Measurement of screw thread and gear:** Terminology of screw threads, measurement of major diameter, minor diameter, pitch, angle and effective diameter of screw threads by 2-wire and 3- wire methods, best size wire. Screw thread gauges, Tool maker's microscope. Gear tooth terminology, tooth thickness measurement using constant chord	**10 Hrs**

method, addendum comparator method and base tangent method, measurement of pitch, concentricity, run out, and involute profile. Gear roll tester for composite error. **Advances in metrology:** Basic concepts of lasers, advantages of lasers, laser interferometers, types, applications. Basic concepts of Coordinate Measuring Machines-constructional features, applications.	
MODULE - 4: **Measurement systems and basic concepts of measurement methods:** Definition, significance of measurement, generalized measurement system, definitions and concept of accuracy, precision, calibration, threshold, sensitivity, hysteresis, repeatability, linearity, loading effect, system response-time delay. Errors in measurement, classification of errors.Transducers, transfer efficiency, primary and secondary transducers, electrical, mechanical, electronic transducers, advantages of each type transducers. **Intermediate modifying and terminating devices:** Mechanical systems, inherent problems, electrical intermediate modifying devices, input circuitry, ballast circuit, electronic amplifiers. Terminating devices, Cathode ray oscilloscope, Oscillographs.	**10 Hrs**
MODULE - 5: **Force, Torque and Pressure Measurement:** Direct methods and indirect method, force measuring inst. Torque measuring inst., Types of dynamometers, Absorption dynamometer, Prony brake and rope brake dynamometer, and power measuring instruments.Pressure measurement, principle, use of elastic members, Bridgeman gauge, McLeod gauge, Pirani gauge. **Measurement of strain and temperature:** Theory of strain gauges, types, electrical resistance strain gauge, preparation and mounting of strain gauges, gauge factor, methods of strain measurement. Temperature Compensation, Wheatstone bridge circuit, orientation of strain gauges for force and torque, Strain gauge bBASED load cells and torque sensors.	**10 Hrs**

Text books:

T1. "**Mechanical Measurement**"– Beckwith Marangoni and Lienhard, Pearson education, 6th Ed.2006.

T2. "**Engineering Metrology**" – by R. K. Jain, Khanna Publishers, 1994.

Reference Books:

R1. "**Engineering Metrology**" - I.C. Gupta, Dhanpat Rai Publications, Delhi.

R2. "**Mechanical Measurements**" – by R. K. Jain, Khanna Publishers, 1994.

R3. "**Industrial Instrumentation"-** Alsutko, Jerry.D.Faulk, Cengage Asia Pvt. Ltd. 2002.

R4. "**Measurement systems Applications and Design**" – Ernest O Doebelin, 5th Ed, McGraw Hill Book Co.

R4. "**Metrology and Measurement**" Anand K. Bewoor and Vinay A. Kulkarni, Tata McGraw

Hill Pvt. Ltd, New Delhi.

Evaluation Scheme:

Assessment	Marks
Internal assessment test	20
VTU Semester examination	80
Total	100

Course Description:

Overview of the course:

The course content basically deals with two parts Engineering Metrology and Engineering Measurements. The Metrology part deals with the different types of standards, limits, fits and tolerances and the measurements of screw thread profiles, gear terminology, etc. The measurements part deals with classification of errors and various types of measurement techniques used for measurement of temperature, strain, force, pressure, torque etc.

Relevance of the course:

Today the industrial processing and manufacturing techniques have become so much complex and complicated that their control is beyond the reach of human judgment. The exact and precise measurements are the basic essentials of automatic controls. The whole foundation of process industries, power plants and other industries is solely based on the advancement in the art and science of measurements. Words of Lord Kelvin" I often say that when you can measure what you are speaking about and express it in numbers you know something about it; but when

you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind.' This statement presents a powerful case for the subject.

Application areas:

Manufacturing is significant activity for a nation's wealth creation and overall prosperity. Without measurement manufacturing looks incomplete. The various techniques of measurements are used in industries for the measurement of various parameters by the quality control department. Without this quality could never have achieved.

Prerequisites:

This subject requires the knowledge of metric and SI units of physical quantities, Statistics and trigonometry.

Course Outcomes (COs): The student should be able to

1. **Identify** the objectives of metrology in mechanical engineering and acquire knowledge of various standards of measurements and **discuss** the difference between Limits, Fits, and Tolerances and organize the classification of comparators, outline the principle involved in angular measurements.
2. **Apply** different methods to measure screw thread and gear tooth terminologies.
3. **Explain** the generalized measurement system and identify the working of intermediate & terminating devices.
4. **Outline** the measurement of force, torque and pressure with different methods.
5. **Discussing** the methods of measurements of temperature and strain with different principles.

Module wise lesson plan

Course code and Title: Mechanical Measurements and Metrology (15ME36B)	
Module I **Introduction to Metrology & Linear Measurement and angular measurements**	Planned Hours: **10 hrs**

Learning Objectives: At the end of the chapter student should be able to

1. Discuss basics of metrology and objectives.
2. Outline conservation and transfer of units of measurements and their standards.
3. Select the slip gauge for building specific lengths.
4. Compare line and end standards.

5. Utilize angle gauges and build for specific angle.
6. Discuss Sine bar, Sine center and clinometers principle.

Lesson Schedule:

Lecture No.	Portion to be covered per lecture (class)	Teaching Method	PO attained	COs attained	Reference Book/Chapter No
L1	Introduction to Metrology, Definition and objectives,	Chalk and Board	a,e	1	T2/2, R1/2
L2	Standards of length – International prototype meter, Standards and types,	Chalk and Board		1	T2/2, R1/2
L3	Slip gauges, wringing phenomenon,	Chalk and Board		1	T2/2, R1/2
L4	Problems on slip gages	Chalk and Board		1	T2/2, R1/2
L5	Line and End standards, Calibrations of standards	Chalk and Board		1	T2/2, R1/2
L6	Problems on Calibration	Chalk and Board		1	T2/2, R1/2
L7	Sine Principle, Sine bar,	Chalk and Board		1	T2/5, R1/5
L8	Sine center, Auto collimator	Chalk and Board		1	T2/5, R1/5
L9	Angle Gauges, Bevel protractor	Chalk and Board		1	T2/5, R1/5
L10	Angle Gauges (simple problems) Clinometers	Chalk and Board		1	T2/5, R1/5

Assignments:

Questions	Cos attained
1. What is a slip gauge? Explain the wringing phenomena of slip gauges with sketch.	1
2. Classify the standards of measurement.	1
3. Construct the following dimensions with M112 slip gauge set 33.345 mm, 45.324 mm, 57.867 mm and 84.5795 mm.	1
4. Define metrology. What are the objectives of metrology from an industrial point of view?	1
5. Explain wavelength standard of length.	1
6. What are Airy points? Explain with sketch.	1
7. Distinguish between line and end measurements	1
8. Describe the method of transfer from line standard to end standard.	1
9. Explain the principle of Sine bar and Sine center with sketch.	1
10. Explain with sketch the principle of autocollimeter and interferometry.	1

Module wise lesson plan

Course code and Title: Mechanical Measurements and Metrology (15ME36B)	
Module 2 **System of Limits, Fits, Tolerances and Comparators**	Planned Hours: 10 **hrs**

Learning Objectives: At the end of the chapter student should be able to

1. Discuss the standards called as tolerances, limits and fits.
2. Identify the magnitude of permissible variation of a dimension or other measured or control criterion from the specified value.
3. Compare hole and Shaft basis system.

4. Outline the types of gauges.
5. Design the gauges.
6. Outline the types of comparators
7. Explain different mechanical, optical and electrical comparators.
8. Utilize angle gauges and build for specific angle.
9. Discuss Sine bar, Sine center and clinometers principle.

Lesson Schedule:

Lecture No.	Portion to be covered per lecture (class)	Teaching Method	POs attained	COs attained	Reference Book/Chapter No
L11	Introduction to limits, fits and tolerances, Definition of tolerance,	Chalk and Board	a,b,e,k	2	T2/4, R1/9
L12	Types of tolerance,	Chalk and Board		2	T2/4, R1/9
L13	Hole basis and shaft basis system,	Chalk and Board		2	T2/4, R1/9
L14	Classification of gauges	Chalk and Board		2	T2/4
L15	Taylor's principle, types of gauges	Chalk and Board		2	T2/4, R1/9
L16	Design of Gauges	Chalk and Board		2	T2/4
L17	Numericals	Chalk and Board		2	T2/4, R1/9
L18	Characteristics and types of comparators,	Chalk and Board		2	T2/5, R1/5
L19	Mechanical comparators	Chalk and Board		2	T2/5, R1/5
L20	Optical and Pneumatic	Chalk		2	T2/5, R1/5

	comparators	and Board			

Assignments:

Questions	Cos attained
1. Define geometrical tolerancing and positional tolerancing. Give examples for each type.	2
2. What is interchangeability? Explain with examples.	2
3. Sketch and explain the terminology in limits and fits.	2
4. Explain Taylor's principle in detail.	2
5. Explain 'clearance', 'interference' and 'transition fits'.	2
6. Find the type of fit for 25H7/f8	2
7. Explain the difference between a comparator and measuring instrument. State the fields of application of comparators.	2
8. What are salient features of a comparator and how are they achieved in the "Sigma comparator"? Explain your answer with sketches.	2
9. Explain any one type of "Electrical and Electronic comparator".	2
10. Sketch and explain (i) "Johansson's Mikrokator". (ii) "Reed type comparator". (iii) "Zeiss ultra-optimeter".	2
11. Explain the principle and operation of optical comparators.	2
	2

Module wise plan

Course code and Title: Mechanical Measurements and Metrology (15ME36B)	
Module 3 **Measurement of screw thread and gear & Advances in metrology**	Planned Hours:10 **hrs**

Learning Objectives: At the end of the chapter student should be able to

1. Demonstrate Interferometry, autocollimator, optical flat principles.
2. Apply different methods for measurement of major diameter, minor diameter, pitch, angle and effective diameter of screw threads.
3. Utilize tool makers microscope and measure terminologies.
4. Utilize gear tooth vernier caliper and micrometer for measurements.

Lesson Schedule:

Lecture No.	Portion to be covered per lecture (class)	Teaching Method	PO attained	COs attained	Reference Book/Chapter No
L21	Principle of interferometer, autocollimator, optical flats.	Chalk and Board	a,b,e,k	3	T2/6
L22	Terminologies of screw threads and its nomenclature.	Chalk and Board		3	T2/6, R1/3
L23	Measurement of major diameter, minor diameter,	Chalk and Board		3	T2/6, R1/3
L24	Measurement of pitch, angle of screw threads.	Chalk and Board		3	T2/6, R1/3
L25	Measurement of effective diameter of screw threads by 2-wire and 3-wire methods, best size wire.	Chalk and Board		3	T2/6, R1/3
L26	Gear terminology and use of gear tooth vernier caliper, Tool makers microscope.	Chalk and Board		3	T2/6, R1/3
L27	Basic concepts of Lasers, advantages of Lasers	Chalk and Board		3	T2/6, R1/3
L28	Laser Interferometers, types, applications	Chalk and Board		3	T2/6, R1/3
L29	Basic concept of Coordinate Measuring machines-constructional features	Chalk and Board		3	T2/6, R1/3
L30	Applications	Chalk and Board		3	T2/6, R1/3

Assignments:

Questions	Cos attained
1. Explain the difference between a comparator and measuring instrument. State the fields of application of comparators.	3
2. What are salient features of a comparator and how are they achieved in the "Sigma comparator"? Explain your answer with sketches.	3
3. Explain any one type of "Electrical and Electronic comparator".	3
4. Sketch and explain (i) "Johansson's Mikrokator". (ii) "Reed type comparator". (iii) "Zeiss ultra-optimeter".	3
5. Explain the principle and operation of optical comparators.	3
6. Explain the principle of Sine bar and Sine center with sketch.	3
7. Explain with sketch the principle of autocollimeter and interferometry.	3

Module wise plan

Course code and Title: Mechanical Measurements and Metrology (15ME36B)	
Module 4 **Measurement systems and basic concepts of measurement methods & Intermediate modifying and terminating devices:**	Planned Hours: 10hrs

Learning Objectives: At the end of the chapter student should be able to

1. Discuss Generalized measurement system
2. Explain concept of accuracy, precision, calibration, sensitivity, threshold, hysteresis, repeatability, linearity, system response-time delay, loading effect etc.
3. Discuss Transducers, transfer efficiency, primary and secondary transducers, electrical, mechanical, electronic transducers
4. Discuss electrical intermediate devices
5. Identify input circuit, ballast circuit, electronic amplifiers and telemetry.
6. Explain terminating devices.
7. Discuss cathode ray oscilloscope, Oscillographs, XY-plotter.

Lesson Schedule:

Lecture No.	Portion to be covered per lecture (class)	Teaching Method	POs attained	COs attained	Reference Book/Chapter No
L31	Principle of interferometer, autocollimator, optical flats.	Chalk and Board	a,b,e,k	4	T1/1,6 & R4/2
L32	Terminologies of screw threads and its nomenclature.	Chalk and Board		4	T1/1,6 & R4/2
L33	Measurement of major diameter, minor diameter,	Chalk and Board		4	T1/1,6 & R4/2
L34	Measurement of pitch, angle of screw threads.	Chalk and Board		4	T1/1,6 & R4/2
L35	Measurement of effective diameter of screw threads by 2-wire and 3-wire methods, best size wire.	Chalk and Board		4	T1/1,6 & R4/2
L36	Gear terminology and use of gear tooth vernier caliper, Tool makers microscope.	Chalk and Board		4	T1/1,6 & R4/2
L37	Introduction to Intermediate Modifying Devices, Inherent problems of mechanical devices,	Chalk and Board		4	T1/7,9 & R4/12
L38	Electrical I.M. devices, input circuit, ballast circuit	Chalk and Board		4	T1/7,9 & R4/12
L39	Amplifiers – types	Chalk and Board		4	T1/7,9 & R4/12
L40	Telemetry – generalized concepts	Chalk and Board		4	T1/7,9 & R4/12

Assignments:

Questions	Cos attained
1. What is measurement? Explain the requirements and significance of measurement systems.	4
2. Explain with an example the three stages of a generalized	4

measurement system.	
3. What do you understand by the following terms? Explain with sketches. a) Repeatability b) Sensitivity c) Static calibration d) Hysteresis e) Threshold f) Linearity	4
4. Describe the following types of errors, and state how they can be taken care of. a) Environmental errors b) Parallax error c) Errors due to vibration.	4
5. Explain the following terms 1) Transfer efficiency 2) Primary transducer 3) Secondary transducer	4
6. Explain with a neat sketch electronic type of transducer.	4
7. What are the inherent problems of mechanical IM devices?	4
8. Explain with a neat sketch and a graph the ballistic circuit.	4
9. What is an amplifier? How are amplifiers classified?	4
10. What is CRO? Explain its principle, construction and working with a neat sketch.	4
11. Explain with sketch the working of an oscillograph.	4
12. Explain with sketch the working of XY plotters.	4

Module wise lesson plan

Course code and Title: Mechanical Measurements and Metrology (15ME36B)	
Module5 **Measurements and measurement systems**	Planned Hours: 1**0 hrs**

Learning Objectives: At the end of the chapter student should be able to

1. Analyze principles involved in Analytical balance, Platform balance, Proving range
2. Utilize Prony brake hydraulic dynamometer for Torque measurement
3. Explain the principles involved in the measurement of Pressure
4. Utilize Bridgeman gear, Mc-load gauge and Pirani gauge.
5. Explain Resistance thermometers, thermocouple and optical pyrometer.
6. Outline Laws of thermocouple, Materials used for construction of thermocouples.
7. Discuss strain measurements, strain gauge, preparation and mounting of Strain Gauge, Gauge factor, Methods of Strain measurement.

Lesson Schedule:

Lecture No.	Portion to be covered per lecture (class)	Teaching Method	PO attained	COs attained	Reference Book/Chapter No
L41	Principle of analytical balance	Chalk and	a,b,e,k	5	T1/13,14 & R4/5

		Board			
L42	Platform balance, Proving range,	Chalk and Board		5	T1/13,14 & R4/5
L43	Torque measurement: prony brake, hydraulic dynamometer	Chalk and Board		5	T1/13,14 & R4/5
L44	Use of elastic members	Chalk and Board		5	T1/13,14 & R4/5
L45	Bridgeman gauge, Mc load gauge,	Chalk and Board		5	T1/13,14 & R4/5
L46	Pirani gauge	Chalk and Board		5	T1/13,14 & R4/5
L47	Temperature Measurements- Resistance Thermometer	Chalk and Board		5	T1/12,16 & R4/8
L48	Laws of thermocouple	Chalk and Board		5	T1/12,16 & R4/8
L49	Materials used for construction, Pyrometer	Chalk and Board		5	T1/12,16 & R4/8
L50	Optical Pyrometer	Chalk and Board		5	T1/12,16

Assignments:

Questions	Cos attained
1. Explain with sketch the principle and working of i) Analytical balance ii) platform balance iii) Proving wring.	5
2. Explain with sketch hydraulic dynamometer.	5
3. Explain with sketches the various elastic members used for pressure measurement.	5
4. Explain with sketch the Bridgeman gauge used for pressure measurements.	5
5. Explain with sketches i) Mc Load Gauge ii) Pirani Gauge.	5

6. What is thermocouple? Explain the two laws of thermocouple	5
7. What is pyrometer? Explain with a neat sketch and optical pyrometer.	5
8. What are the various materials used for the construction of thermocouples?	5
9. What is the strain gauge? Explain the procedure of preparation and mounting of strain gauges	5
10. Explain the terms – i) gauge factor ii) poison's ratio	5
11. Explain the various methods of strain measurements	5