A) Course Code : 2037471(037)
B) Course Title : Theory of Machines
C) Pre- requisite Course Code and Title :
D) Rationale :

Mechanical Machines are back bone of any industry. Hence, knowledge of various mechanisms and machines is a pre-requisite for enabling a mechanical engineer to work in an industry. The aim of the course is to provide exposure to the basic mechanisms and machines to enhance their capability. This course provides the knowledge of kinematics and dynamics of different machine elements and popular mechanisms such as four link mechanisms, cam-follower, belt-pulley, chain sprocket, gears, flywheel, brake and clutch to enable a diploma holder to carry out maintenance and selection of these. This course also serves as a prerequisite for course 'Elements of Machine Design' to be studied in later semester. Knowledge of these aspects will help the student to understand and improve insight into the practical applications of machines and mechanisms.

E) Course Outcomes:

CO-1 Select suitable mechanism for various applications.

CO-2 Estimate velocity and acceleration of planar mechanisms.

CO-3 Select relevant brakes and clutches for various applications.

CO-4 Estimate motion related parameters for different cam-follower combinations.

CO-5 Select relevant belts, chains and gear drives for different power transmission applications.

CO-6 Select suitable flywheel and governor for various applications.

CO-7 Estimate magnitude and location of unbalanced rotating mass and fundamental information about vibration phenomenon.

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) L+T+(P/2)
1.	Mechanical Engineering	2037471(037)	Theory of Machines	2	-	1	3
2.	Mechanical Engineering	2037461(037)	Theory of Machines (Lab)	-	2	-	1

Legend: L: Classroom Instruction (Includes different instructional strategies i.e. Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) T- Tutorial includes Sessional Work(SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credits

Note: SW and SL have to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1.	Mechanical Engineering	2037471(037)	Theory of Machines	70	20	30	-	-	120
2.	Mechanical Engineering	2037461(037)	Theory of Machines(Lab)	-	-	-	30	50	80

Note: i. Separate passing is must for TA component of Progressive Assessment, both for theory and practical.
ii. Separate passing is must for End Semester Exam (Theory) and End Semester Exam (Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (P), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Select suitable mechanism for various applications.

(Approx. Hrs: L+P+T=8)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Identify various links in the given mechanism and their functions. SO1.2 Identify the inversions of a given mechanism. SO1.3 Describe the constructional details of the given mechanism. SO1.4 Select suitable mechanism for the given application with justification.	LE1.1 Draw line diagrams with dimensions of the working models of all the inversions of Slider Crank Mechanism available in the lab. LE1.2 Draw line diagrams with dimensions of the working models of all the inversions of Double Slider Crank Mechanism available in the lab. LE1.3 Draw line diagrams with dimensions of the working models of all the inversions of Four bar Mechanism available in the lab. LE1.4 Dismantle and assemble wiper mechanism of any four wheeler. LE1.5 Draw bicycle brake applying mechanism and identify the type of links and joints.	**Unit-1.0 Popular Planar Mechanisms** 1.1 Kinematics of Machines: Introduction to Statics, Kinematics, Kinetics, Dynamics. Mechanism and machine, rigid and resistant bodies, Kinematic links, joints, pairs, chain and its types, degree of freedom, Constrained motion and its types. 1.2 Four link planar mechanisms and Inversions: i. Four bar chain: Locomotive coupler, Beam engine and Pantograph. ii. Single slider Crank chain: Pendulum pump, Rotary I.C. engine mechanism, Oscillating cylinder engine, Whitworth quick return Mechanism, Quick return mechanism of shaper. iii. Double Slider chain: Scotch Yoke mechanism, Elliptical trammels, Oldham's Coupling.	• Introduction to Mechanisms and Machines • Straight line mechanisms

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Compare wiper mechanism of a typical bus with wiper mechanism of a typical car.
ii. Compare slider crank mechanism used in a Bike and a Car.
iii. Study a sewing machine and prepare a list of various mechanisms used in it.

b. Mini Project:

i. Prepare card sheet/stick/thermocole models of at least four mechanisms (group work with group size of five students each)

c. Other Activities (Specify):

i. Prepare a list of different mechanisms used in automobile, domestic appliances, devices, industrial machines etc. (group work with group size of five students each)

ii. Collect photographs of all the mechanisms identified in Sr. no. (i) and prepare a chart (group work with group size of five students each)

CO-2 Estimate velocity and acceleration of planar mechanisms.

(Approx. Hrs: L+P+T=10)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Draw dimensioned sketch of the given mechanism. SO2.2 Explain procedure to draw velocity diagram for a given mechanism using relative velocity method. SO2.3 Explain procedure to draw acceleration diagram for the given mechanism. SO2.4 Use analytical method (without derivation) to calculate velocity and acceleration of links in the given single slider crank mechanism SO2.5 Draw velocity and acceleration diagram for the given slider crank mechanism using Klein's construction. SO2.6 Estimate velocity and acceleration of any link at any instant in the given mechanism.	LE2.1 Draw velocity diagram for a given mechanism using relative velocity method. LE2.2 Draw acceleration diagram for the given mechanism. LE2.3 Measure important kinematic data related to following mechanisms and sketch them. a) Bicycle free wheel sprocket mechanism b) Geneva mechanism LE2.4 Measure important kinematic data related to following mechanisms and sketch them. a) Ackerman's steering gear mechanism b) Foot operated air pump mechanism	**Unit-2.0 Velocity and Acceleration in Mechanisms** 2.1 Concept of relative velocity and relative acceleration of a point on a link, angular acceleration, inter-relation between linear and angular velocity and acceleration. 2.2 Analytical method and Klein's construction to determine velocity and acceleration of different links in single slider crank mechanism. 2.3 Velocity and acceleration diagrams for simple mechanisms. 2.4 Determination of velocity and acceleration of point on link by relative velocity method (Excluding Coriollis component of acceleration) 2.5 Mechanical advantage calculation.	• Use of software to simulate motion of different mechanisms (free software like '2D working Model' software)

SW-2 Suggested Sessional Work (SW) :

a. Assignments:

i. List industrial applications of higher and lower pairs.

ii. Compare theoretical Kinematic diagram of Hand pump mechanism with actual hand pump and justify the difference.

b. Micro Project:

i. Prepare working model of four bar kinematic chain (crank-crank) in workshop using wood/acrylic sheets and measure the angular displacement of output link for a given angular displacement of input link.

ii. Measure the ratio of time of cutting stroke to the return stroke in shaping machine available in institute's workshop by varying the stroke length. Following activities need to be performed:
- Measuring dimensions of different links of given shaper machine
- Sketching
- Labeling of sketch

c. Other Activities (Specify):

i. Visit your institute workshop, identify the type of mechanism used in different machines and prepare a report.

CO- 3 Select relevant brakes and clutches for various applications.

(Approx. Hrs: **L+P+T**=12)

Session Outcomes (SOs)	Laboratory Instruction (L)	Class room Instruction (P)	Self Learning (SL)
SO3.1 Identifies the application of friction in given engineering application. SO3.2 Explain various parts of the given brakes with their functions and constructional details. SO3.3 Describe working principle of the given clutch(s). SO3.4 Explain various parts of the given clutch with their functions and constructional details. SO3.5 Determine the power transmitted by the given clutch through simple numerical situation. SO3.6 Calculate braking force, braking torque and power lost in	LE3.1 Determine friction in collar bearing LE3.2 Dismantle and assemble a single plate clutch. LE3.3 Dismantle and assemble a multi plate clutch. LE3.4 Dismantle and assemble a centrifugal clutch. LE3.5 Dismantle and assemble an internal expanding brake and Disc Brake. LE3.6 Estimate torque transmitting capacity of single and multi plate clutch with the help of working model. LE3.7 Interpret the specification of the given Ball and Taper Roller bearing and note down the dynamic load, Static load and Inner diameter etc. different bearing parameters from the	**Unit-3.0 Application of Friction** 3.1 **Clutches:** Classification, Functions and Applications, Construction and principle of working of i. Single-plate clutch, ii. Multi-plate clutch, iii. Centrifugal Clutch iv. Cone clutch v. Diaphragm clutch. 3.2 Calculation of power loss assuming uniform pressure and uniform wear theory. **3.3 Brakes:** Functions, Types, Applications 3.4 Construction and working principle of i. Shoe brake ii. Band brake iii. Internal expanding shoe brake iv. Disc Brake 3.5 Braking force, braking torque and power for shoe and band	• Diaphragm Clutch • Hydrodynamic Journal Bearing

Session Outcomes (SOs)	Laboratory Instruction (L)	Class room Instruction (P)	Self Learning (SL)
friction in the given shoe and band brake through simple numerical situation. SO3.7 Calculate power lost in friction in the given bearing through simple numerical situations. SO3.8 Interpret the given bearing designation.	SKF and NBC Manufacturing Catalogue. LE3.8 Use rope brake dynamometer to calculate power in an IC Engine.	brakes. 3.6 Dynamometer: Meaning need and type. 3.7 **Bearings:** Classification of bearings – rolling contact and sliding contact bearings, types of rolling contact bearings and types of sliding contact bearings, advantages and disadvantages of rolling and sliding contact bearing and their application, Designation of bearings.	

SW-3 Suggested Sessional Work (SW) :

a. Assignments:

i. Solve numerical problems related to Brakes, Clutches and Bearings.
ii. Write names and specification of bearings used in a typical Bike.
iii. Write names and specification of brakes used in a different two, three and four wheelers.

b. Micro Project:

i. Bring scrap single plate clutch and a Multi-Plate clutch and compare them based on, Number of plates, Radial Dimension, Weight, Construction, Working, Operating Media (Dry/Wet), Torque transmission etc. (group work with group size of five students each).
ii. Collect scrap rolling bearings of different types and correlate their specifications with manufacturer catalog.

c. Other Activities (Specify):

i. Draw assembly drawing of an internal expanding Brake and Disc Brake of a Car.
ii. Collect information about different dynamometers and give a seminar on the same.

CO-4 Estimate motion related parameters for different cam-follower combinations.

(Approx. Hrs: **L+P+T**=12)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Explain different types of cams and cam followers with their motions. SO4.2 Explain motion and displacement	LE4.1 Demonstrate working of any one type of cam and followers. LE4.2 Prepare one sheet on construction of cam profile for given	**Unit 4.0 Cams and Followers** 4.1 Introduction to Cams and Followers. Cam and follower terminology. Classification of Cams	• Types of follower and their applications • Types of Radial cams and their

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
of the given cam and follower SO4.3 Estimate velocity and acceleration diagram for given cam and follower. SO4.4 Construct different types of cam profile from the given data. SO4.5 Draw dimensioned sketch of the given cam and follower arrangement. SO4.6 Identify the type of motion of follower in the given situation with justification. SO4.7 Draw cam profile for the given motion of knife-edge and roller follower with and without offset application using Graphical method.	data (without offset). This should include one case of knife edge follower and another of roller follower. LE4.3 Prepare one sheet on construction of cam profile for given data (with offset). This should include one case of knife edge follower and another of roller follower. LE4.4 Measure main dimension of a Tangent flank cam and estimate lift, velocity and acceleration at critical points.	and Followers. Applications of Cams and Followers. 4.2 Types of follower motions-uniform velocity, uniform acceleration and S.H.M and their displacement, velocity and acceleration diagrams. 4.3 Drawing of profile of a radial cam based on given motion of reciprocating knife-edge and roller follower with and without offset.	applications • Cam with specified contours: Tangent Cam and Convex flank Cam

SW-4 Suggested Sessional Work (SW) :

a. Assignments:

i. List the various types of machine where Cam and Follower are used.
ii. Draw a radial Cam profile with oscillating follower.

b. Micro Project:

i. Collect different Cam and Follower combinations used in different devices and machines. (group work with group size of five students each).
ii. Develop Acrylic models of various Cam-Follower combinations.

c. Other Activities (Specify):

i. Prepare a slide show of working animation of cam and follower using open source software.
ii. Collect specified contours Cams (Tangent Cams and Convex flanks Cams) from scarp market.

CO-5 Select relevant belts, chains and gear drives for different power transmission applications.

(Approx. Hrs: L+P+T=14)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Calculate velocity ratio, belt tensions, slip and angle of contact in the given belt drive arrangement SO5.2 Estimate power transmitted and condition for maximum power transmission in the given belt drive through simple numerical situation. SO5.3 Select suitable belt for the given application with justification. SO5.4 Calculate Train value & velocity ratio for the given gear trains using spur and helical gears only. SO5.5 Select suitable gear for the given application with justification. SO5.6 Select suitable drives for the given application with justification. SO5.7 Identify the different types of gear trains and their field of applications.	LE5.1 Measure slack side and tight side tension in belt of pulleys of a floor mill. LE5.2 Measure slack side and tight side tension in Chain of sprocket of a Bicycle. LE5.3 Select V-belt for a given application through manufacturer catalog and justify LE5.4 Analysis and Working of gears in Lathe machine gear box. LE5.5 Analysis and Working of gears in Sugar cane crushing machine. LE5.6 Analysis and Working of gears in Differential of automobile LE5.7 Analysis and Working of gears in Gear box of two wheelers LE5.8 Analysis and Working of gears in Hand Drilling Machine	**Unit-5.0 Power Transmission** 5.1 Belt Drives – Introduction to Flat belt, V-belt & its applications, materials used for flat and V-belts. Introduction of timing belt and pulley. Angle of lap, length of belt, Slip and creep. Determination of velocity ratio of tight side and slack side tension, centrifugal tension and initial tension, condition for maximum power transmission. Merits, demerits and selection of belts for given applications. 5.2 Chain Drives – Introduction to chain drives, Types of chains and sprockets, Methods of lubrication. Merits, demerits and selection of chains for given applications. 5.3 Gear Drives – Introduction to gear drives, Classification of gears, Law of gearing, gear terminology, 5.4 Gear trains- Types of gear, simple, compound, reverted and epicyclic gear train. Computation of velocity ratio in gear train.	• Timer Belt • Differential of automobile

SW-5 Suggested Sessional Work (SW) :

a. Assignments:

i. Calculate velocity ratio, belt tensions, slip and angle of contact in the given belt drive arrangement through simple numerical situation.
ii. Estimate power transmitted and condition for maximum power transmission in the given belt drive through simple numerical situation.

b. Micro Project:

i. Collect five samples of different types of used belts and fix them on a single board with labels. (group work with group size of five students each).
ii. Collect different types of gears from scrap market and fix them on a single board with labels. (Group work with group size of five students each).
iii. Explain the complete procedure of selection of a V-belt for a particular application using manufacturers catalog.

c. Other Activities (Specify): Collect five photographs of different Epicyclic gear trains used in different devices.

CO-6 Select suitable flywheel and governor for various applications.

(Approx. Hrs: L+P+T=13)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO6.1 Differentiate between flywheel and governor. SO6.2 Apply the concept of fluctuation of speed and energy for the given flywheel. SO6.3 Draw a turning moment diagram for a given engine. SO6.4 Identify the working of different types of governor and their function. SO6.5 Calculate the lift in case of given governor. SO6.6 Estimate mass and other geometric parameters of a given flywheel for given situation.	LE6.1 Determine the fluctuation of energy of two stroke and four stroke petrol engines and justify the size of flywheels. LE6.2 Calculate and prepare turning moment diagram from given experimental data. LE6.3 Estimate the lift of all the governors at different speeds using the test rig. LE6.4 Measure the Kinetic Energy stored in the given flywheel after 15 seconds for a given starting torque.	**Unit 6.0 Flywheel and Governors** 6.1 Dynamics of reciprocating engine mechanism, inertia force due to reciprocating mass. 6.2 Piston effort, crank effort, turning moment of crank shaft. 6.3 Fluctuation of energy and speed, coefficient of fluctuation of energy and speed. (No derivation) 6.4 Principle and application of flywheel. 6.5 Governor- Function of governor and its comparison with flywheel. 6.6 Classification of governor, Watt, Porter, Proell, Hartnell governor their construction and working. 6.7 Equation for lift of governors. (No derivation) 6.8 Terms related to	• Inertia Governors • Pickering Governor

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		governor like Sensitivity, stability, Isochronous, Governor effort and power. (No derivation)	

SW-6 Suggested Sessional Work (SW) :

a. Assignments:

i. Identify and measure the dimensions of Flywheel used in various automobiles.
ii. Draw a turning moment diagram for a given engine through simple numerical situation.
iii. Calculate mass of flywheel and coefficient of fluctuation of a flywheel through simple numerical situation.

b. Mini Project: Calculate the size/mass of flywheel fitted to a shearing or punching machine and justify.

c. Other Activities (Specify): Collect photographs of various governors and flywheels fitted to different engine.

CO-7 Estimate magnitude and location of unbalanced rotating mass and fundamental information about vibration phenomenon.

(Approx. Hrs: L+P+T=11)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO7.1 Explain the method of balancing a rotating mass as per the given conditions. SO7.2 Estimate the balancing mass and its position analytically and graphically for many given unbalance masses rotating in a single plane. SO7.3 Explain the different types of vibrations. SO7.4 Estimate the natural frequency of single degree of freedom systems.	LE7.1 Perform balancing of a Car Tyre LE7.2 Perform balancing of many unbalanced rotating masses in single plane using rotating balancing machine.	**Unit-7.0 Balancing of Rotating and Reciprocating unbalanced masses and vibrations** 7.1 Balancing- Need and types of balancing, Effects of unbalanced masses. 7.2 Balancing of rotating masses in same plane- Analytical and Graphical methods for balancing of several masses revolving in same plane. 7.3 Balancing of reciprocating masses. (No numerical examples). 7.4 Elements of vibrations, natural frequency of single degree of freedom systems.	• Balancing of single rotating mass in different plane. • Damped and Un-damped systems • Forced vibration.

SW-7 Suggested Sessional Work (SW) :

a. Assignments:

i. Estimate the balancing mass and its position analytically and graphically for many given unbalance masses rotating in a single plane through a numerical situation.

b. Micro Project:

i. Take wheel of a car and perform balancing with the help of a 'Vehicle Alignment and Balancing Shop' and justify the position and magnitude of Balancing mass used through analytical method.

c. Other Activities (Specify): Collect photographs of various rotating mass balancing machines.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESE of Classroom Instruction) :

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Popular Planar Mechanisms	-	2	8	10
II	Velocity and Acceleration in Mechanisms	-	2	8	10
III	Application of Friction	3	-	4	7
IV	Cams and Followers	3	-	4	7
V	Power Transmission	-	3	7	10
VI	Flywheel and Governors	-	3	7	10
VII	Balancing of Rotating and Reciprocating unbalanced masses and vibrations	1	3	12	16
Total		**7**	**13**	**50**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Working models of all the inversions of Slider Crank Mechanism.	15	10	5
LE1.2	Working models of all the inversions of Double Slider Crank Mechanism available in the lab	15	10	5
LE1.3	Working models of all the inversions of Four bar Mechanism available in the lab.	15	10	5
LE1.4	Dismantle and assemble wiper mechanism of any four-wheeler.	15	10	5
LE1.5	Bicycle brake applying mechanism	15	10	5
LE2.1	Draw velocity diagram for a given mechanism using relative velocity method.	15	10	5
LE2.2	Draw acceleration diagram for the given mechanism.	15	10	5
LE2.3	Measure important kinematic data related to following mechanisms and sketch them. a) Bicycle free wheel sprocket mechanism b) Geneva mechanism	15	10	5
LE2.4	Measure important kinematic data related to following mechanisms and sketch them.	15	10	5

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
	a) Ackerman's steering gear mechanism b) Foot operated air pump mechanism			
LE3.1	Determine friction in collar bearing.	15	10	5
LE3.2	Dismantle and Assemble a single plate clutch.	15	10	5
LE3.3	Dismantle and Assemble a multi plate clutch.	15	10	5
LE3.4	Dismantle and Assemble a centrifugal clutch.	15	10	5
LE3.5	Dismantle and Assemble a internal expanding brake and Disc Brake.	15	10	5
LE3.6	Estimate torque transmitting capacity of single and multi plate clutch with the help of working model.	15	10	5
LE3.7	Selection of Ball and Taper Roller bearing from the SKF and NBC Manufacturing Catalogue.	15	10	5
LE3.8	Use rope brake dynamometer to calculate power in an IC Engine.	15	10	5
LE4.1	Demonstrate working of any one type of cam and followers.	15	10	5
LE4.2	Prepare one sheet on construction of cam profile for given data (without offset). This should include one case of knife edge follower and another of roller follower.	15	10	5
LE4.3	cam profile for given data (with offset) with knife edge follower and roller follower.	15	10	5
LE4.4	Measure main dimension of a Tangent flank cam and estimate lift, velocity and acceleration at critical points.	15	10	5
LE5.1	Measure slack side and tight side tension in belt of pulleys of a floor mill.	15	10	5
LE5.2	Measure slack side and tight side tension in Chain of sprocket of a Bicycle.	15	10	5
LE5.3	Select V-belt for a given application through manufacturer catalog and justify.	15	10	5
LE5.4	Analysis and Working of gears in Lathe machine gear box.	15	10	5
LE5.5	Analysis and Working of gears in Sugar cane crushing machine.	15	10	5
LE5.6	Analysis and Working of gears in Differential of automobile.	15	10	5
LE5.7	.Analysis and Working of gears in Gear box of two wheelers.	15	10	5
LE5.8	Analysis and Working of gears in Hand Drilling Machine.	15	10	5
LE6.1	Determine the fluctuation of energy of two stroke and four stroke petrol engines and justify the size of flywheels.	15	10	5
LE6.2	Calculate and prepare turning moment diagram from given experimental data.	15	10	5
LE6.3	Estimate the lift of all the governors at different speeds using the test rig.	15	10	5
LE6.4	Measure the Kinetic Energy stored in the given flywheel after 15 seconds for a given starting torque.	15	10	5
LE7.1	Perform balancing of a Car Tyre	15	10	5
LE7.2	Perform balancing of many unbalanced rotating masses in single plane using rotating balancing machine.	15	10	5

*Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practicals .

Legend: PRA: Process Assessment, PDA : Product Assessment

Note: Only one experiment has to be performed at the end semester examination of **30 Marks** as per assessment scheme

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Industrial visits
6. Industrial Training
7. Field Trips
8. Portfolio Based Learning
9. Role Play
10. Demonstration
11. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)
12. Brainstorming
13. Others

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition*
1	Theory of Machines	Rattan S. S.	Tata McGraw-Hill Education	1986, ISBN 9780070591202
2	Theory of Machines	Khurmi R. S., Gupta J. K.	S. Chand Publications, New Delhi	2015, ISBN 9788121925242
3	Theory of Machines	Bevan Thomas	Pearson Education India	1986, 3/e ISBN 9788131729656
4	Theory of Machines and Mechanisms	Ballaney P.L.	Publisher Khanna	2003, 23/e, ISBN 9788174091222
5	A Text Book of Theory of Machines	Bansal R.K., Brar J. S.	Laxmi Publication, New Delhi	2004, ISBN 9788170084181
6	Mechanism and Machine Theory	A G Ambekar	PHI Learining	Revised 2nd Edition, ISBN-9788120331341

*Latest edition of all above books should be referred

(b) Open source software and website address:

1. user.engineering.uiowa.edu/~mie032/support/eg/eg07_section_views.pd
   web.aeromech.usyd.edu.au/.../Engineering%20Drawings%20Lecture%20Sectioning
2. http://nptel.iitm.ac.in/video.php?subjectId=112104121
3. http://www.technologystudent.com/gears1/gears7.htm
4. http://kmoddl.library.cornell.edu/model.php?m=20
5. http://www3.ul.ie/~kirwanp/whatisacamandfollowersyste.htm
6. http://nptel.iitm.ac.in/courses/Webcourse-contents/IIT-Delhi/Kinematics%20of%20Machine/index.htm
7. http://elearning.vtu.ac.in/12/enotes/Des_Mac-Ele2/Unit6-RK.pdf
8. en.wikipedia.org/.../Canadian_Committee_for_the_Theory_of_Machines...

9. global.oup.com/.../theory-of-machines-and-mechanisms-978019537123...
10. www.tecquipment.com/Theory_of_Machines.aspx
11. www.researchgate.net/.../0094-114X_Mechanism_and_Machine_Theory
12. www.journals.elsevier.com/mechanism-and-machine-theory/
13. journalseek.net/cgi-bin/journalseek/journalsearch.cgi?field=issn...
14. site.iugaza.edu.ps/wp-content/.../IUGAZA%20TOM2012_CH1-2.pdf
15. www.iftomm.org/
16. www.wiziq.com/online-tests/44047-mechanical-theory-of-machine
17. www.cs.ubc.ca/~murphyk/Teaching/CS340-Fall07/infoTheory.pdf

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Manufacturers' Catalog
5. Lab Manuals

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	bicycle free wheel sprocket mechanism, Geneva mechanism, Ackerman's steering gear mechanism and foot operated air pump mechanism, slider crank mechanism, hooks joint, inversions of four bar mechanisms- locomotive coupler, Beam engine, Pantograph, Pendulum pump, Rotary I.C. engine mechanism, Oscillating cylinder engine, Whitworth quick return Mechanism, Quick return mechanism of shaper, Scotch Yoke mechanism, Elliptical trammel and Oldham's Coupling.	Working Models / wooden/thermocol Acrylic models/ metallic models	LE1.1 to LE1.5 LE2.1 to LE2.4
2	Friction bearing- all types	Actual	LE3.1,3.7
3	Various types of clutch assemblies.	Working and cut section models	LE3.2, LE3.3, LE3.4, LE3.6
4	Various types of brake assemblies	Working and cut section models	LE3.5
5	Dynamometers - all types	Rope Brake, Eddy current, Electrical	LE3.8
6	Different Types of cams, followers and cam/follower arrangements	Working Models / wooden/thermocol Acrylic models/ metallic models	LE4.1, LE4.2, LE4.3, LE4.4
7	Various belt drives, chain and sprocket, various gear drives.	Actual items	LE5.1, LE5.2. LE5.3, LE5.4, LE5.5
8	Working models of Gear trains - all types. (Simple, compound, reverted, epicyclical).	Working Models/ wooden/thermocol Acrylic models/metallic models	LE5.7, LE5.8
9	Different belts in different arrangements	Working models	LE5.1, LE5.2, LE5.3
10	Any machine having flywheel (Single cylinder 4-Stroke I.C engine with flywheel)		LE6.1, LE6.2, LE6.4
11	Governors - all types	Working Models / wooden/thermocol Acrylic	LE6.3

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
		models/metallic models	
12	Vehicle Tyre balancing machine	Rim Diameter 10"-24" or 265 - 615 mm Rim Width 1.5" - 20" or 40 - 510 mm Distance between wheel and machine 0 - 25 cm. Balancing Accuracy 1 gm. Power Supply 220 - 240 V, 50 - 60 Hz Single Phase Motor 0.33 kW Maximum Power Consumption 0.6 kW. RPM 60 Wheels weighing upto 75 kg Dimensions with Wheel Guard WxLxH1350 (Hood open) x1220x1670 Net Weight with Wheel Guard 160 kg (Excluding Adaptors)	LE7.1
13	Static and Dynamic Balancing Apparatus	Weighing Capacity 10-50kg, Power Source Electric Voltage 240 V Frequency 50 Hz	LE7.2

N) Mapping of POs and PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2	PSO-3
CO-1 Select suitable mechanism for various applications.	2	3	3	2	1	1	3	2	2	2	-	2	1
CO-2 Estimate velocity and acceleration of planar mechanisms.	3	3	3	2	1	1	1	2	2	2	2	2	1
CO-3 Select relevant brakes and clutches for various applications.	1	3	3	2	1	1	3	2	2	2	-	2	1
CO-4 Estimate motion related parameters for different cam-follower combinations.	2	3	3	2	1	1	1	2	2	2	2	2	1
CO-5 Select relevant belts, chains and gear drives for different power transmission applications.	2	3	3	2	1	1	3	2	2	2	-	2	1
CO-6 Select suitable flywheel and governor for various applications.	1	3	3	2	1	1	3	2	2	2	-	2	1
CO-7 Estimate magnitude and location of unbalanced rotating mass and fundamental information about vibration phenomenon.	2	3	3	2	1	1	1	2	2	2	-	2	1

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-1 Select suitable mechanism for various applications.	SO1.1 to SO1.4	LE1.1 to LE1.5	Unit 1.0 Popular Planar Mechanisms: 1.1,1.2	As mentioned in relevant page numbers.
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-2 Estimate velocity and acceleration of planar mechanisms**.**	SO2.1 to SO2.6	LE2.1 to LE2.4	Unit 2.0 Velocity and Acceleration in Mechanisms: 2.1, 2.2, 2.3, 2.4, 2.5	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-3 Select relevant brakes and clutches for various applications.	SO3.1 to SO3.9	LE3.1 to LE3.8	Unit 3.0 Application of Friction: 3.1, 3.2, 3.3,3.4, 3.5, 3.6, 3.7	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-4 Estimate motion related parameters for different cam-follower combinations.	SO4.1 to SO4.7	LE4.1 to LE 4.4	Unit 4.0 Cams and Followers: 4.1, 4.2, 4.3	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-5 Select relevant belts, chains and gear drives for different power transmission applications.	SO5.1 to SO5.7	LE5.1 to LE5.8	Unit 5.0 Power Transmission: 5.1, 5.2, 5.3, 5.4	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-6 Select suitable flywheel and governor for various applications.	SO6.1 to SO6.6	LE6.1 to LE 6.4	Unit 6.0 Flywheel and Governors: 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-7 Estimate magnitude and location of unbalanced rotating mass and fundamental information about vibration phenomenon**.**	SO7.1, SO7.2	LE7.1 to LE 7.2	Unit 7.0 Balancing of Rotating and Reciprocating unbalanced masses and vibrations: 7.1, 7.2, 7.3,7.4	

A) Course Code : 2037472(037)
B) Course Title : Manufacturing Processes
C) Pre- requisite Course Code and Title :
D) Rationale :

Manufacturing is a core area in the field of Mechanical Engineering. The basic knowledge of different manufacturing processes is essential to select the most appropriate process and related parameters for getting the desired results in terms of converting the raw material to finished product as per the requirements. This course on Manufacturing Process aims at providing knowledge regarding different types of manufacturing processes and use of related machines, equipment and tools safely. It also develops understanding to suggest and manipulate vital process parameters related to different manufacturing processes as well as the behavior of metal and change in it during different manufacturing processes.

E) Course Outcomes:

CO-1 Select suitable manufacturing process to produce various components.

CO-2 Prepare product using different casting processes.

CO-3 Prepare product using different forming processes.

CO-4 Use joining process to produce jobs

CO-5 Produce jobs using plastic molding process.

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) L+T+(P/2)
1.	Mechanical Engineering	2037472(037)	Manufacturing Process	2	-	1	3
2.	Mechanical Engineering	2037462(037)	Manufacturing Process**(Lab)**	-	2	-	1

Legend: L: Classroom Instruction (Includes different instructional strategies i.e. Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) T- Tutorial includes Sessional Work(SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credits

Note: SW & SL have to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Mechanical Engineering	2037472(037)	Manufacturing Process	70	20	30	-	-	120
2.	Mechanical Engineering	2037462(037)	Manufacturing Process**(Lab)**	-	-	-	30	50	80

Note: i Separate passing is must for TA component of Progressive Assessment, both for theory and practical.
ii. Separate passing is must for End Semester Exam (Theory) and End Semester Exam(Practical)

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (P), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Select suitable manufacturing process to produce various components.

(Approx. Hrs: L+P+T=14)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Explain basic manufacturing processes. SO1.2 Describe various mechanical properties. SO1.3 Select suitable manufacturing process for the given application with justification.	LE1.1 Identify five domestic/industrial components, select the type of manufacturing process required to produce them with justification	**Unit-1.0 Introduction to Manufacturing Processes** 1.1 Classification of basic manufacturing process based on chip-less and chip-removal processes, Primary and Secondary manufacturing processes, Various generating & forming processes, 1.2 Factors which influence selection of manufacturing process for a particular application. 1.3 Recall mechanical properties of metals.	• Various Mechanical engineering materials • Mechanical properties of materials • Additive and Subtractive manufacturing processes

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i Discuss the advantages and limitations of chip-less and chip-removal processes of manufacturing.

ii Prepare list of domestic and industrial applications of various generating and forming processes of manufacturing.

iii List out at least 10 applications of chip-less processes of manufacturing.

b. Mini Project:

i. Surf www and collect five videos related to manufacturing of different domestic and industrial components and submit it to course coordinator. (Individual student Assignment)

c. Other Activities (Specify):

i. Collect information of manufacturing industries/workshops/shops in your city and vicinity.

CO-2 Prepare product using different casting processes.

(Approx. Hrs: L+P+T=18)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Select pattern allowances for the given application with justification. SO2.2 Interpret the color coding on pattern and core. SO2.3 Select suitable furnace for the given application with justification. SO2.4 Explain the importance of gates and risers. SO2.5 Select appropriate casting process for the given application with justification. SO2.6 Identify casting defects and explain theircauses. SO2.7 Select a suitable inspection method for identifying given defects in the given casting with justification.	LE2.1 Prepare a pattern drawing, pattern and core for the given component or component drawing. LE2.2 Prepare a sand mould using the given single piece pattern. LE2.3 Prepare a sand mould using the given split pattern. LE2.4 Prepare casting using the mould made in 2.2 and wax in place of molten metal.	**Unit-2.0 Metal Casting** 2.1 Definition and Need 2.2 Pattern: types, materials, pattern allowances, color code, applications 2.3 Cores: Need, types, materials 2.4 Moulds: Molding sand: Types, properties, binders, additives, mixing, Molding equipments & tools Type of moulds, mould making, applications 2.5 Melting of metal: Pit furnace, Cupola, Induction furnace 2.6 Metal pouring: Gates and Risers. 2.7 Casting Processes: Dry sand mould casting, Shell mould casting, Investment casting, Die casting, Centrifugal casting. 2.8 Casting defects: Blow, scar, blister, gas holes, pin holes, porosity, drop, inclusion, dross, dirt, wash, buckle, scab, rat tail, penetration, swell, misrun, cold shut, hot tear, shrinkage cavity, mould shift, core shift and 2.9 Inspection of castings: Visual inspection, pressure test, magnetic particle inspection, dye penetration inspection, Radiographic inspection, ultrasonic inspection. 2.10 Safety precautions in metal casting.	• Slush casting, Permanent mould or Gravity die casting

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i Identify the factors affecting the selection of pattern material for a given application.
ii Compare and prepare a chart showing the applications of various types of patterns.
iii Identify the need of core prints.
iv Sketch the gating system for pouring metal in a casting.
v Explain the effect of grain size and shape of molding sand.
vi Explain the causes and remedies of common casting defects.

b. Micro Project:

i Visit a nearby foundry and prepare a report comprising of details (type, material, process, etc) of items produced, quantities, consumables and equipment used with specification, process parameters being used.
ii Surf www and identify five domestic/industrial components produced by casting processes. Write steps of its manufacturing and materials, machines and tools used. (Individual student Assignment)

c. Other Activities (Specify):

i Prepare a chart to show the different tools used for making patterns.
ii Compare and prepare a chart showing the advantages, disadvantages and applications of different casting methods.
iii Prepare a chart showing the various casting defects and ways to prevent them.
iv Prepare a chart showing the methods for identifying various casting defects.

CO-3 Prepare product using different forming processes.

(Approx. Hrs: L+P+T=16)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.1 Explain Cold and Hot working processes and their effects on metal properties. SO3.2 Select relevant forming process for the given application or component with justification.	LE3.1 Prepare aluminum washer using flywheel press. LE3.2 Prepare two jobs using hot forging.	**Unit-3.0 Metal Forming and Press working** 3.1 Cold and Hot working of metals, effect on metal properties, advantages & limitations. 3.2 Forming processes, types, working principle, tools and equipment, applications of: Rolling, Forging, Drawing, Deep drawing, Extrusion. 3.3 Safety precautions. 3.4 Press working: Emphasis that press working is not forming process, Punching, Blanking, Notching, Lancing, Slitting, Nibbling, Trimming.	• Wire drawing • Flexible plastic pipe manufacturing • Stretch Forming

SW-3 Suggested Sessional Work (SW) :

a. Assignments:

i Explain the importance of recrystallisation temperature in mechanical working of metals.
ii Prepare a list of methods used for production of pipes and tubes.
iii Compare the cold working and hot working of metals.
iv Prepare a chart showing the different sheet metal operations.

b. Micro Project:

i Visit a nearby Rolling mill/allied manufacturing processes industry and prepare a report comprising of details(type, material, process, etc) of items produced, quantities, different sections, equipments used with specification, process parameters being used.
ii Surf www and identify five domestic/industrial components produced by forming processes. Write steps of its manufacturing and materials, machines and tools used. (Individual student Assignment)

c. Other Activities (Specify):

i Collect information on various extrusion machines.
ii Collect information on various forging machines.
iii Collect information on different deep drawing punch and dies.

CO-4 Use joining process to produce jobs.

(Approx. Hrs: L+P+T=16)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Explain different welding processes. SO4.2 Suggest appropriate welding process for the given application with justification. SO4.3 Identify weld defects and their causes. SO4.4 Practice safe practices during joining processes.	LE4.1 Prepare a lap joint using spot welding equipment. LE4.2 Use seam welding to join two sheets of metal. LE4.3 Prepare a V – Butt joint using TIG welding. LE4.4 Use MIG welding to join the given metal pipe. LE4.5 Prepare a Balcony grill using welding of stainless Steel pipes.	**Unit 4.0 Metal Joining** 4.1 Classification, recall gas and arc welding processes. 4.2 Working principle, equipment, sketch, process parameters, applications of: (i) MIG, TIG, Flux coated arc and submerged arc (ii) Resistance welding – Butt, Seam, Spot, Projection and Percussion. (iii) Thermit welding. (iv) Forged welding 4.3 Effects of welding heat 4.4 Weld defects and their causes. 4.5 Safety precautions in welding.	• Laser welding and Electron beam welding • Friction welding and Explosive welding • Welding of Stainless Steel

SW-4 Suggested Sessional Work (SW) :

a. Assignments:

i List the advantages, disadvantages and applications of welding over other joining processes.
ii Compare the merits, demerits and applications of MIG and TIG.
iii Distinguish Thermit welding from Manual arc welding.
iv Compare spot and seam welding.

b. Micro Project:

i Visit a nearby fabrication industry and prepare a report comprises of types of item produced, quantities, different sections, equipments used with specification and consumables.
ii Surf www and identify five domestic/industrial components produced by Welding processes. Write steps of its manufacturing and materials, machines and tools used. (Individual student Assignment)

c. Other Activities (Specify):
i Prepare a chart showing the detailed classification of welding process.
ii Collect information on various welding machines.
iii Collect information on welding of stainless steel and Aluminum.
iv Collect information on Plastic pipe welding

CO-5 Produce jobs using plastic molding process.

(Approx. Hrs: L+P+T=16)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Suggest appropriate plastic molding method for the given application/component with justification. SO5.2 Explain the concept of powder metallurgy and its applications.	LE5.1 Prepare a given job using blow molding process. LE5.2 Prepare a job using injection molding process.	**Unit-5.0 Plastic Molding and Powder Metallurgy** 5.1 Plastic Molding: Concept, working principle, equipment and applications of Compression molding, Blow molding, Injection molding and Extrusion. 5.2 Safety precautions. 5.3 Powder Metallurgy: Introduction, advantages and disadvantages, Powder metallurgy processes: Powder making, blending, compacting, sintering, infiltration and impregnation, Applications 5.4 Safety Precautions.	• Application of Blow molding

SW-5 Suggested Sessional Work (SW) :

a. Assignments:
i List the applications of different plastic molding processes.
ii Identify and explain the main stages of powder metallurgy process.
iii Write down the applications of powder metallurgy process.
iv Compare the powder metallurgy process with other manufacturing processes.

b. Micro Project:
i Visit a nearby plastic industry and prepare a report comprising of types of item produced, quantities, consumables and equipment used with specification and consumables.
ii Surf www and identify five domestic/industrial components produced by Plastic and blow molding processes. Write steps of its manufacturing and materials, machines and tools used. (Individual student Assignment)

c. Other Activities (Specify):

i Collect information on various plastic injection machines.

ii Collect information on various Blow molding machines

I) Suggested Specification Table (For ESE of Classroom Instruction CI+SW+SL):

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Introduction to Manufacturing Processes	2	2	2	6
II	Metal Casting	**2**	4	12	18
III	Metal Forming and Press Working	**2**	**4**	12	18
IV	Metal Joining	**2**	**4**	10	16
V	Plastic Molding and Powder Metallurgy	**2**	**4**	6	12
Total		**10**	**18**	**42**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Identify five domestic/industrial components, select the type of manufacturing process required to produce them with justification	15	10	5
LE2.1	Prepare a pattern drawing, pattern and core for a given component or component drawing.	15	10	5
LE2.2	Prepare a sand mould using a given single piece pattern.	15	10	5
LE2.3	Prepare a sand mould using a given split piece pattern.	15	10	5
LE2.4	Prepare casting using the mould made in LE2.2 and wax in place of molten metal.	15	10	5
LE3.1	Prepare aluminum washer using flywheel press.	15	10	5
LE3.2	Prepare two jobs using hot forging.	15	10	5
LE4.1	Prepare a lap joint using spot welding equipment.	15	10	5
LE 4.2	Use seam welding to join two sheets of metal.	15	10	5
LE 4.3	Prepare a V – Butt joint using TIG welding.	15	10	5
LE 4.4	Use MIG welding to join given metal pipe.	15	10	5
LE 4.5	Prepare a Balcony grill using welding of stainless Steel pipes.	15	10	5
LE5.1	Prepare a given job using blow molding process.	15	10	5
LE5.2	Prepare a job using injection molding process.	15	10	5

*Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practicals ,

Legend: PRA: Process Assessment, PDA : Product Assessment

Note: Only one experiment has to be performed at the end semester examination of **30 Marks** as per assessment scheme

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial

3. Case Method
4. Group Discussion
5. Industrial visits
6. Industrial Training
7. Field Trips
8. Portfolio Based Learning
9. Role Play
10. Demonstration
11. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)
12. Brainstorming
13. Others

L) Suggested Learning Resources:

(a) Books :

S. No.	Title	Author	Publisher and Edition*
1	Material Science and Metallurgy	O. P. Khanna	Dhanpat Rai Publishing Company Private Limited, New Delhi ISBN 13: 9789383182459
2	Manufacturing Science	Amitabha Ghosh and Asok Kumar Malik	Affiliated East West Press Pvt Ltd. ISBN 13: 9780745800592
3	Manufacturing Technology	R. K. Rajput	CBS,2 edition, 2006, ISBN-10: 8123908946 ISBN-13: 978-8123908946
4	Manufacturing Process	O. P. Khanna	Dhanpat Rai Publishing Company Private Limited, New Delhi ISBN: 9788189928230, 8189928236
5	Introduction to Basic Manufacturing Processes and Workshop Technology	Rajender Singh	New Age International ISBN (13) : 978-81-224-2316-7
6	Production Technology	R. K. Jain	Khanna Publishers ISBN 10: 8174090991 ISBN 13: 9788174090997
7	Production Technology	P. C. Sharma	S. Chand Publishing ISBN:9788121911146
8	Basic Manufacturing Processes, Theory & Practice	R. C. S. Mehta, N. S. Gaira	Viva Books Pvt. Ltd. ISBN: 9789386243928,
9	Elements of Workshop Technology Vol. I	Hajra Choudhury	Media Promoters and Publishers Pvt Ltd. ISBN 090621601X, 9780906216019
10	Workshop Technology Vol. I	B. S. Raghuwanshi	Dhanpat Rai and Sons ISBN-13: 5551234001924.
11	Manufacturing Technology Vol. I & II	P. N. Rao	McGraw Hill ISBN: 9781259062575 (Vol. 1) ISBN:9789332901018 (Vol 2)
12	Workshop Technology Vol. I	H. S. Bawa	Tata McGraw Hill ISBN (13): 9780074600269

*Latest edition of all above books should be referred

(b) Open source software and website address:

1. Manufacturing process NPTEL Courses- http://nptel.ac.in/courses/112107145/

2. Casting methods-https://www.youtube.com/results?search_query=basic+of+casting+process
3. Casting defects- https://www.youtube.com/results?search_query=casting+ deffects+
4. Moulding methods- https://www.youtube.com/results?search_query=moulding+methods
5. Hot working - https://www.youtube.com/results?search_query=hot+ working+methods
6. Extrusion Process- https://www.youtube.com/watch?v=Y75IQksBb0M
7. Rolling process - https://www.youtube.com/results?search_query=rolling+process
8. Metal spinning- https://www.youtube.com/results?search_query=metal+spinning
9. Wire drawing- https://www.youtube.com/results?search_query=wire+drawin
10. Forging methods- https://www.youtube.com/results?search_query=forging+ methods
11. Welding process - https://www.youtube.com/results?search_query=welding+ process
12. Effects of heat treatment processes on material properties- https://www.youtube.com/results?search_query=Effects+of+heat+treatment+processes+on+material+properties

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	Foundry tools and equipments – hand riddle, shovel, Hand, peen & floor rammer, sprue pin, strike off bar, mallet, draw spike, vent rod, lifters, trowels, slicks, smoothers, swab, spirit level, gate cutter, gaggers, nails and wire pieces, clamps, cotters and wedges, Molding box, crucible etc.	As per requirement	LE2.1 to LE2.4
2	Flywheel Press/Hydraulic Press	1 - 5 ton capacity suitable for small products like washers etc.	LE3.1
3	Hot Forging equipment	Standard hot forging press suitable for forging small parts complete with all tools and accessories.	LE3.2
4	Spot welding machine	15 KVA, Input voltage 330 – 440 Volt, Air cooled transformer	LE4.1
5	Seam welding machine	75 KVA, Weld head: Cylinder dia 100 mm, stroke 100 mm,	LE4.2
6	MIG welding machine	Standard MIG welding machine for welding of low carbon steel, stainless steel, aluminum etc.	LE4.4
7	TIG welding machine	3 phase, 230-415 Volt	LE4.3
8	Blow molding machine	Hydraulically/pneumatically operated Standard machine, product size 30-50 ml, mould cavity – 2	LE5.1
9	Injection molding machine	Electrically operated standard machine suitable for small products like bottle caps, combs, buckets etc.	LE5.2

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2	PSO-3
CO-1 Select suitable manufacturing process for given component	2	3	1	3	2	2	2	2	2	2	-	2	3
CO-2 Prepare product using different casting processes.	3	3	3	3	2	2	2	2	2	2	1	3	3
CO-3 Prepare product using different forming processes.	1	3	3	3	2	2	2	2	2	2	1	3	3
CO-4 Use joining process to produce jobs	2	3	3	3	2	2	2	2	2	2	1	3	3
CO-5 Produce jobs using plastic molding process.	2	3	3	3	2	2	2	2	2	2	1	3	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-1 Select suitable manufacturing process for given component	SO1.1 SO1.2 SO1.3	LE1.1	Unit-1.0 Introduction to Manufacturing Processes 1.1,1.2,1.3	As mentioned in relevant page numbers.
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-2 Prepare product using different casting processes.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5 SO2.6 SO2.7	LE2.1 LE2.2 LE2.3 LE2.4	Unit-2.0 Metal Casting 2.1,2.2,2.3,2.4,2.5,2.6.2.7.2.8.2.9, 2.10	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-3 Prepare product using different forming processes.	SO3.1 SO3.2	LE3.1 LE3.2	Unit-3.0 Metal Forming and Press working 3.1, 3.2, 3.3,3.4	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-4 Use joining process to produce jobs	SO4.1 SO4.2 SO4.3 SO4.4	LE4.1 LE4.2 LE4.3 LE4.4 LE4.5	Unit-4.0 Metal Joining 4.1, 4.2,4.3, 4.4, 4.5	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-5 Produce jobs using plastic molding process.	SO5.1 SO5.2	LE5.1 LE5.2	Unit-5.0 Plastic Molding and Powder Metallurgy 5.1, 5.2, 5.3, 5.4	

A) Course Code : 2037473(037)
B) Course Title : Industrial Measurements & Control
C) Pre- requisite Course Code and Title :
D) Rationale :

The art of Measurements and Control plays an important role in engineering. There are significant changes in measurement techniques with recent advancements in technology, with many types of instrumentation devices, innovations, refinements. The course aims at making a Mechanical Engineering student familiar with the principles of measurements and controls, transducers & measurement of mechanical parameters like temperature, pressure, flow, speed, force and stress.

E) Course Outcomes:

CO-1 Use relevant measuring instrument as per the requirement.

CO-2 Use control system for the given industrial application.

CO-3 Use relevant instruments for displacement and speed measurement.

CO-4 Use temperature measuring instruments.

CO-5 Use flow measurements and pressure measurements instruments.

CO-6 Use strain measuring instruments to measure strain.

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) L+T+(P/2)
1.	Mechanical Engineering	2037473(037)	Industrial Measurements & Control	2	-	1	3
2.	Mechanical Engineering	2037463(037)	Industrial Measurements & Control(Lab)	-	2	-	1

Legend: L: Classroom Instruction (Includes different instructional strategies i.e. Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) T- Tutorial includes Sessional Work(SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credits

Note: SW & SL have to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Mechanical Engineering	2037473(037)	Industrial Measurements & Control	70	20	30	-	-	120
2.	Mechanical Engineering	2037463(037)	Industrial Measurements & Control(Lab)	-	-	-	30	50	80

Note:i Separate passing is must for TA component of Progressive Assessment, both for theory and practical.
ii. Separate passing is must for End Semester Exam(Theory) and End Semester Exam(Practical)

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (P), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Use relevant measuring instrument as per the requirement.

(Approx. Hrs: L+P+T=13)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Describe standards to measure the given parameters SO1.2 Analyze various sensors based on its classification and working principle. SO1.3 Use appropriate sensors for multidisciplinary applications SO1.4 Explain the construction and working principle of the given transducer. SO1.5 Select relevant transducer for the given application with justification SO1.6 Compute the statistical error analysis.	LE1.1 Identify the contact and non-contact transducers from the given samples of transducers. LE1.2 Measure the distance using ultrasonic transducers. LE1.3 Measure the vibration parameters using Piezo-electric Transducer	**Unit-1.0 Measurement System**. 1.1 Introduction to measurement and measuring instruments, Classification of measuring Instruments, their characteristics like sensitivity, accuracy, linearity, threshold, resolution, etc. 1.2 Measuring system, Block diagram with example, stages of measuring system with examples – Stage I input signal (detector transducers), Stage II (intermediate modifying), and Stage III (terminating), Types of input signals. 1.3 Measurement standards :- Time, frequency, Voltage, Current, 3-15 psi etc., ANSI, ASME, ADA, BS, DIN, CSMR, FCI, API, ISI, and introduction Reliability and safety. 1.4 Transducers –primary and secondary transducers, classification, working principle of resistance, inductance, capacitance and piezoelectric transducers with their line sketches, applications of each, sensors, types and applications, difference between transducer and sensor.	• Statistical analysis of errors in sensors and Transducers • Sensing process and physical laws.

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. The typical specifications for a pressure transducer are given below interpret the specifications
- Measurement range: 0 – 1000 mm of Water
- Temperature range: 0 – 50^0 C nominal at 25^0 C
- Linearity error: ± 0.5 % of Full Scale
- Sensitivity error: ± 0.20% of reading
- Hysteresis error: Less than 0.10% of full scale
- Thermal sensitivity error: 0.01%/^{0} C of reading from 25^0 C
- Thermal zero drift: 0.01% of full scale from 25^0 C

ii. Explain the working principle of resistance, inductance, capacitance and piezo electric transducers with line sketches.

iii. Give three specific examples of transducers used in the following measurements:
- Temperature measurement
- Pressure measurement
- Flow measurement

State for each example the input and analogous output quantities and also identify primary and secondary transducer in each of the above examples.

b. Mini Project:

i. Collect and chart out the specifications and applications of various measuring instruments..

ii. Collect and chart out the specifications and applications of various sensors.

c. Other Activities (Specify):

i. Visit to nearby industry to identify the different applications of transducers and sensors and prepare a report on it.

CO-2 Use control system for the given industrial application.

(Approx. Hrs: L+P+T=15)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Explains with sketch the functions of different elements of the given open loop and closed loop control systems. SO2.2 Explain with sketch the given control system component. SO2.3 Explain with sketch PI, PD and PID Controllers. SO2.4 Select control system component for the given	LE2.1 Identify different elements of the given open loop and closed loop control systems LE2.2 Control the temperature of an oven by using ON/OFF controller.	**Unit-2.0 Introduction to Control system** 2.1 Definition , Basic terminology, Objective of control system, Types of Control Systems, Effect of Feedback Systems, 2.2 Basic elements of open and closed loop system, concept of open loop and closed loop systems, Block diagram of Open loop and closed loop control systems, Effect of feedback, multivariable control	• Servomotor mechanism • Comparison of hydraulic, pneumatic, electronic control systems.

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
situation with justification. .		systems comparison, Applications and advantage 2.3 Time Response of feedback control systems: Standard test signals -unit step, ramp, impulse and parabolic 2.4 Process Control and its benefits, Basic control actions, Two position or On/Off control, Introduction to PI, PD and PID Controllers. 2.5 Control System Components: construction and working, concept of ac servomotor, synchronous and stepper motor	

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Draw the block diagram of the control system for following cases:
   (a) Student – Teacher learning process
   (b) Automobile interior cabin temperature control system
   (c) Steering system of an automobile
   (d) Refrigerator
   (e) Door bell
   (f) Automatic washing machine
ii. Explain the benefits of feedback in control systems.
iii. Given a situation or application, suggest the type of control system with justification.

b. Mini Project:

i. Prepare a report on the control systems used in air conditioners.
ii. Prepare a report on the control system used in CNC machine
iii. Identify various control system used in automobile and write a report on its construction, working and its functions.
iv. Design a small mobile based control system for home automation.

c. Other Activities (Specify):

i. Visit to nearby manufacturing industry (any -2) and write a report on the control system used in various manufacturing process in the industry.
ii. Write a report on Finger Print and speech recognition based control system.

CO- 3 Use relevant instruments for displacement and speed measurement

(Approx. Hrs: **L+P+T=13**)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.1 Explain with sketch the working principle of the given differential transformer. SO3.2 Explain with sketch the working principle of the given tachometer. SO3.3 Select relevant displacement measuring instrument for the given application with justification SO3.4 Select relevant speed measuring instrument for the given application with justification.	LE3.1 Measure the displacement of core using LVDT. LE3.2 Measure the displacement using Capacitive Transducer: LE3.3 Measure the speed of a motor shaft using Stroboscope. LE3.4 Measure the speed of an electric motor with given type of tachometer.	**Unit-3.0 Displacement and speed measurement** 3.1 Working principle & use of Potentiometer, Differential transformer (LVDT & RVDT), capacitive element & Optical encoders. 3.2 Mechanical tachometer, Electrical Tachometer, incremental optical encoder, Eddy current drag cup tachometer. 3.3 Magnetic pickup tachometer, Stroboscopic tachometer, Photoelectric tachometer, non contacting electrical tachometer (inductive pick up & capacitive pick up)	• Magnetic and photoelectric pulse counting methods • Contactless Electrical tachometer • Inductive Pick Up, Capacitive Pick Up

SW-3 Suggested Sessional Work (SW):

a. Assignments:

i. Draw simple line sketch of LVDT and prepare a list of applications of LVDT in industry.
ii. Prepare a detailed report on applications of tachometers in industrial measurements.

b. Mini Project:

i. Collect information regarding speed measuring instruments and prepare a report along with their specifications for following applications:
   (a) Engine speed
   (b) Speed of a moving vehicle
   (c) Speed of wind
   (d) Acceleration of a vehicle
   (e) Speed of a vehicle moving in traffic

c. Other Activities (Specify):

i Prepare a power point presentation on applications of non contacting electrical tachometer (inductive and capacitive pick up).

CO- 4 Use temperature measuring instruments.

(Approx. Hrs: L+P+T=13)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Explain the principles on which the given temperature measuring devices work. SO4.2 Explain with sketch the construction and working principle of the given temperature measuring devices. SO4.3 Select relevant temperature measuring device for a given set of data or application with justification. SO4.4 Explain the given type of errors involved in temperature measurement with reasons for error. SO4.5 Explain the calibration methods of temperature measuring instruments.	LE4.1 Measure the temperature with different devices e.g. glass thermometer, bimetallic thermometer, RTD, thermocouple and compare the results. LE4.2 Calibrate the Thermocouple for temperature measurement. LE4.3 Verify the resistance temperature characteristics of given thermistor.	**Unit-4.0 Temperature measurement** 4.1 Principles of temperature measuring devices – change in physical state, expansion, electrical resistance, thermoelectric emf, intensity of radiation, change in chemical state. 4.2 Construction, working, measuring range, accuracy, applications, limitations of devices operating on above principles (Bimetal thermometer, pressure spring thermometer, electrical resistance thermometer, thermister, thermocouple, pyrometer). 4.3 Errors in temperature measurement i. Instrument error – calibration error, ambient temperature error, hysteresis error. ii. Thermal probe error – time lay error, conduction error, radiation error, velocity of error. 4.4 Calibration of temperature measuring instruments - Direct comparison method, fixed point method.	• Quartz thermometer • Hot wire anemometer for temperature measurement

SW-4 Suggested Sessional Work (SW) :

a. **Assignment**s:
   i. Given a handout or bar chart containing approximate range of various temperature measuring devices, select a suitable instrument for the given temperature.
   ii. Prepare a chart showing the working range of different resistance wires used in resistance thermometer.
   iii. Prepare a report on materials used for thermocouples including the cost, output, accuracy, resistance against erosion, suitability for temperature measurement and field of application.

b. Mini Project:

iii. Prepare a comparative chart on temperature measuring devices on the basis of following:
(a) Measuring range
(b) Accuracy
(c) Field of application/suitability
(d) Limitations

iv. Visit a nearby industry/power plant to make a survey on use of temperature measuring devices and prepare a report including their specifications, range and accuracy.

c. Other Activities (Specify):

i. Organise a seminar on applications of resistance temperature detectors (RTD)/Thermocouples/Pyrometers.

CO- 5 Use flow measurements and pressure measurements instruments.

(Approx. Hrs: **L+P+T=14**)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Select relevant flow meter for the given situation with justification. SO5.2 Select relevant pressure measuring device for measurement of pressure in the given situation with justification. SO5.3 Explain with sketch the construction and working of the given flow measuring device. SO5.4 Explain with sketch the construction and working of the given pressure measuring device.	LE5.1 Measure the flow of running liquid using Rotameter. LE5.2 Measure Pressure using bellows. LE5.3 Measure Pressure using diaphragms. LE5.4 Measure Pressure Using Bourdon Pressure Gauge. LE5.5 Calibrate a given Pressure Gauge Using Dead Weight Pressure Gauge Tester.	**Unit 5.0 Flow and Pressure measurement** **(A) Flow measurement** 5.1 Classify flow measuring devices as Volumetric or primary or quantity meters and rate of flow or velocity or secondary meters, their function and examples. 5.2 Volumetric or Primary meters - Bellow type meter, Rotating impeller type meter, Positive displacement meter, Rotating lobe meter, Nutating disc meter Their function, working principle, sketches, applications and limitations. 5.3 Rate of flow or Secondary meters – Obstruction meters • Orifice • Venturimeter • Flow nozzles, • Variable area meter • Pitot tube Velocity probes • Total pressure probes, • Static pressure probes,	• Electrical resistance type Flow meter

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		• Direction sensing probes Special meters • Turbine meter • Hot wire anemometer, Magnetic flow meter Their function, working principle, sketches, applications and limitations. **(B) Pressure Measurement** 5.4 Classify pressure measuring devices – Manometer, Elastic gauges • Diaphragm • Pressure capsules, • Bellows • Pressure springs Electronic pressure sensors/Transducers - Resistance, Inductance and Capacitive type 5.5 There function, principle, working, sketches, applications and limitations of above pressure measuring devices. 5.6 Low pressure gauges- McLeod Gauge, Pirani gauge. 5.7 Calibration of pressure gauges using Dead weight Pressure tester.	

SW-5 Suggested Sessional Work (SW):

a. Assignments:

i. Quote five examples of use of volumetric meters in day to day lfe.
ii. Distinguish between bellow type, rotating impeller and rotating lobo meter on the basis of working principle, area of application and their relative merits and demerits.
iii. Prepare a report on applications of turbine meter, magnetic flow meter and hot wire anemometer.
iv. Identify at least 10 practical situations where pressure measurement is necessary.
v. Given a practical situation with range of pressure to be measured:
(a) Select the most appropriate device for pressure measurement.
(b) Mention the criteria on which the choice is based.

b. Mini Project:

i. Prepare a comparative report on various obstruction flow meters on the basis of accuracy, pressure recovery, resistance to abrasion, suitability for viscous flow, suitability for liquids containing traces of vapor, suitability for gases containing traces of condensate, cost, space requirement, installation and applications.

c. Other Activities (Specify):

i. Survey type of flow measurement devices used in municipal domestic water supply lines.
ii. Seminar on Low pressure measurement devices.

CO- 6 Use relevant instruments for measurement of strain.

(Approx. Hrs: L+P+T=12)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO6.1 Selects the relevant strain gauges for measuring strain in the given system with justification. SO6.2 Describe with sketches the procedure for measurement of strain in the given system using strain gauge.	LE6.1 Measurement of strain on a beam using strain gauge LE6.2 Determine the modulus of elasticity of a cantilever beam using strain gauges (Both static and dynamic loading can be used).	**UNIT 6.0 Strain measurements** 6.1 Strain Measurement- Stress-strain relation, types of strain gauges, strain gauge materials 6.2 Resistance strain gauge- bonded and unbonded, types (foil, semiconductor, wire wound gauges), 6.3 Selection and installation of strain gauges, load cells, Strain rosettes	• Diffused metal strain gauges • Sputter deposited thin metal strain gauges

SW-6 Suggested Sessional Work (SW) :

a. Assignments:

i. Explain how strain gauges are specified?.
ii. Explain the gauge factor and how it is determined?
iii. Quote at least ten industrial applications where load cells are used.

b. Mini Project:

i. Strain gauge needs to be supported by a carrier. Prepare a brief report on different carrier materials available.
ii. Prepare a brief report on the different glues available for pasting a strain gauge? What aspects decide their selection?

c. Other Activities (Specify):

i. Survey type of strain gauges used in industries.
ii. Seminar on load cells and their applications.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESE of Classroom Instruction):

Unit Number	Unit Title	Marks Distribution			Total Marks
		R	U	A	
I	Measurement System.	2	2	6	10
II	Introduction to Control system	2	4	6	12
III	Displacement and speed measurement	2	2	6	10
IV	Temperature measurements	2	4	8	14
V	Flow and Pressure measurements	2	4	6	12
VI	Strain measurements	2	4	6	12
	Total	**12**	**20**	**38**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Title	Assessment of Laboratory work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE-1.1	Identify the contact and non-contact transducers from the given samples of transducers.	15	10	5
LE-1.2	Measure the distance using ultrasonic transducers.	15	10	5
LE-1.3	Measure the vibration parameters using Piezo-electric Transducer	15	10	5
LE-2.1	Identify different elements of the given open loop and closed loop control systems	15	10	5
LE-2.2	Control the temperature of an oven by using ON/OFF controller.	15	10	5
LE-3.1	Measure the displacement of core using LVDT.	15	10	5
LE-3.2	Measure the displacement using Capacitive Transducer:	15	10	5
LE-3.3	Measure the speed of a motor shaft using Stroboscope.	15	10	5
LE-3.4	Measure the speed of an electric motor with given type of tachometer.	15	10	5
LE-4.1	Measure the temperature with different devices e.g. glass thermometer, bimetallic thermometer, RTD, thermocouple and compare the results.	15	10	5
LE-4.2	Calibrate the Thermocouple for temperature measurement.	15	10	5
LE-4.3	Verify the resistance temperature characteristics of given thermistor.	15	10	5
LE-5.1	Measure the flow of running liquid using Rotameter.	15	10	5
LE-5.2	Measure Pressure using bellows.	15	10	5
LE-5.3	Measure Pressure using diaphragms.	15	10	5
LE-5.4	Measure Pressure Using Bourdon Pressure Gauge.	15	10	5
LE-5.5	Calibrate a given Pressure Gauge Using Dead Weight Pressure Gauge Tester.	15	10	5
LE-6.1	Measurement of strain on a beam using strain gauge	15	10	5
LE-6.2	Determine the modulus of elasticity of a cantilever	15	10	5

	beam using strain gauges (Both static and dynamic loading can be used).			

*Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practicals.

Legend: PRA: Process Assessment, PDA: Product Assessment

Note: Only one experiment has to be performed at the end semester examination of 30 Marks as per assessment scheme

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Group Discussion
4. Industrial visits
5. Industrial Training
6. Field Trips
7. Portfolio Based Learning
8. Demonstration
9. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)

L) Suggested Learning Resources:

(a) Books :

S.No.	Title of Book	Author	Publication	Edition & Year
1	Mechanical measurements and instrumentation	Rajput R.K.	S.K.Kataria and Sons, New Delhi, ISBN:978-93-5014-285-1	Edition (2013), 2013
2	Mechanical Measurement and Control	Jalgaonkar R.V.	Everest Publishing House, New Delhi, ISBN-9788186314265.	18th Edition, 2010
3	Mechanical and Industrial Measurements	Jain R.K.	Khanna Publications, New Delhi, ISBN: 978-8174091912	2012
4	Fundamentals of Industrial Instrumentation and Process Control	Dunn William	McGraw Hill Publications, New Delhi, ISBN-10: 0070677492 ISBN-13: 978-070677494	Latest Edition 2017
5	Instrumentation, Measurement and Analysis	Nakra B. C.; Chaudhary K.K.	McGraw Hill Publications, New Delhi, ISBN:0070482969	2010

(b) Open source software and website address:

1 Measurement System
- https://www.youtube.com /watch?v=xcvNl1HHY9o
- http://nptel.ac.in/courses/112106138
- *https://www.khanacademy.org/math/cc-fourth...measurement.../metric-distance*
- https://www.youtube.com/watch?v=VpmZjIsV4C4
- https://www.youtube.com/watch?v=XQT6RSNN9sA
- https://www.youtube.com/watch?v=FgNAlKTTNtE
- https://www.youtube.com/watch?v=sLZeR7RMGFA

2 Introduction to Control system
- https://www.youtube.com/watch?v=XMfH2P2Fc6Q

- https://www.youtube.com/watch?v=g53tqrBjlg
- https://www.youtube.com/watch?v=R9Y_pYBMgRs
- https://www.youtube.com/watch?v=-ZLlJfI8kqI
- https://www.youtube.com/watch?v=FurC2unHeXI
- https://www.youtube.com/watch?v=O-OqgFE9SD4
- https://www.youtube.com/watch?v=vWzUnJwQG6o
- https://www.youtube.com/watch?v=BTW9WQ5tCsY

3 Displacement and speed measurement
- https://www.youtube.com/watch?v=Die29LS1EAs
- https://www.youtube.com/watch?v=Die29LS1EAs
- https://www.khanacademy.org/.../displacement-velocity.../calculating-average-velocity...

4 Temperature measurements
- *https://www.youtube.com/watch?v=As5kzxkyT24*
- *https://www.youtube.com/watch?v=J157oziu3zQ*
- *https://www.youtube.com/watch?v=GNOI_7ftbQ0*
- *https://www.youtube.com/watch?v=JKuoQ5FV2c8*

5 Flow and Pressure measurements
- https://www.youtube.com/watch?v=R9MJEjgrUq
- *https://www.youtube.com/watch?v=sHmjE21Fp9w*
- *https://www.youtube.com/watch?v=iMIzApq1CQ0*
- *https://www.youtube.com/watch?v=5q-WBYhR94Y*
- *https://www.youtube.com/watch?v=RARjXXaFEQ0*
- *https://www.youtube.com/watch?v=gByrUkZUnKo*
- *https://www.youtube.com/watch?v=F2AOyQKpWSY*
- *https://www.youtube.com/watch?v=oUd4WxjoHKY*
- *https://www.youtube.com/watch?v=DD2bBLu6kLM*

6 Strain measurements
- https://www.youtube.com/watch?v=lUjBmV4wMtA
- *https://www.youtube.com/watch?v=X4H0HaFQPJA*

(c) Others:

1. Learning Packages.
2. Lab Manuals.
3. Manufacturers' Manual
4. Users' Guide

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment No.
1	Ultrasonic transducer	-	LE 1.1,1.2
2	Piezo electric Transducer	-	LE 1.1, 1.3
3	LVDT	Complete LVDT set up with Micrometer (±10 mm Capacity) and Digital displacement Indicator for measuring the displacement.	LE3.1
4	Capacitive transducer	Range up to 5000 RPM display – LED digital	LE3.2
5	Stroboscope	Display : 5-10mm LED with back light Operating Temperature & Humidity : 0 deg C-50 deg C,<85%RH Stroboscopic range 5 to 100,000 FPM/RPM Measurement Range detecting distance 50 to 150 mm	LE3.3
6	Tachometer – Electrical &	Reference rod and outer ring should be anodized	LE3.4

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment No.
	Mechanical	aluminum. Reference Rod : Approx 1/4" diameter, 6" long Bearing Limits: Approx 4000 RPM max. speed Sensor Mounting, threaded hole std. Electrical Specifications Output Frequency: 30 pulses/rev.	
7	Glass thermometer, Bimetallic thermometer	Bi metallic thermometer • Dual Scale Ranges to 1,000°F (525°C) Hermetically Sealed Case Design • 3" and 5" Dials • Stem Lengths to approx 24" • 1% Full Scale Accuracy Glass thermometer • Yellow Capillary • Temperature measurement in a range of -10 to +360 Degree Celsius • Mercury filled	LE 4.1
8	RTD Tutor	– ceramic Body ,Temperature range: -200 ^{o}C to 350 ^{o}C ,Size: Φ1.5 x 16(L) mm	LE 4.1
9	Thermocouple Tutor	Sensor- type k (Cr- Al)thermocouple, sensor assembly and water bath with heating arrangement Display3.5digit digital display	LE 4.1, 4.2
10	Thermister tutor	DISPLAY: 3 ½ Digit LED Display of 200 mV FSD. INITIAL SET: Single turn potentiometer to set Initial Temperature (Room Temperature) FINAL TEST : Single turn potentiometer to Calibrate the instrument (Max. Temperature) SELECT: 3 Way rotary switch to select Thermister. POWER ON: Rocker switch to control power supply to the instrument.	LE4.3
11	Rotameter trainer	Standard glass rotameter, process tank with motor pump Display- float position on graduated scale.	LE5.1
12	Differential Pressure Bellows	Range 0-80" water column to 0-800" water column (or Equivalent) Uni-Directional or Bi-Directional Accuracy ±1% F.S. Standard, ± 1/2% F.S. Optional Dial Size 6" (Standard), 4-1/2" (Optional)Working Pressure up to 6000 PSIG (400 bar)Material of Construction – Body Aluminum, Brass, Carbon Steel, 316/316L Stainless Steel Materials of Construction - Internals Copper Alloy or Stainless Steel	LE5.2
13	Diaphragm Pressure Gauge	dial size : 150mm : mercury / gas actuated stem & bulb :SS 316 stem & bulb DIA : 6mm, 8mm, 10mm & 12mm stem length (std.) : up to 300mm capillary material : MS / SS 316 micro bore capillary protection : SS 304 tubing, pvc, SS armored dial	LE5.3
14	Sensor - Bourdon tube C type with digital Display	3.5 digit display for pressure/ displacement	LE 5.4
15	Dead Weight Pressure Tester	Dimension: 375 (W) X 425 (L) X 350 (H) mm, pressure range 0.6kg/cm^2 to 60 kg/cm^2	LE 5.5
16	Strain Gauge Kit with	Parameter Measured : Strain in terms of grams on a cantilever beam	LE 6.1, LE 6.2

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment No.
	Cantilever	Transducer : Temperature compensated strain gauge Type : Cu-Ni foil with polyamide carrier base Gauge Resistance : 350 Ohms (Nominal) Gauge Length : 6mm Gauge Width : 4 mm Gauge Base : 5 mm x 4.3 mm Gauge Factor : 2:1 (approx.) With complete mounting accessories.	

N) Mapping of Pos & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1 Modern Software Usage	PSO-2 Equipment and Instruments	PSO-3 Mechanical Engineering Processes
CO-1 Use relevant measuring instrument as per the requirement	3	3	3	3	2	2	2	3	2	3	2	3	3
CO-2 Use control system for the given industrial application.	3	3	3	3	2	2	2	3	2	3	2	3	3
CO-3 Use relevant instruments for displacement and speed measurement.	3	3	3	3	2	2	2	3	2	3	2	3	3
CO-4 Use temperature measuring instruments.	3	3	3	3	2	2	2	3	2	3	2	3	3
CO-5 Use flow measurements and pressure measurements instruments.	3	3	3	3	2	2	2	3	2	3	2	3	3
CO-6 Use strain measuring instruments to measure strain.	3	3	3	3	2	2	2	3	2	3	2	3	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-1 Use relevant measuring instrument as per the requirement	SO1.1,SO1.2,SO1.3 SO1.4, SO1.5 SO1.6	LE-1.1,LE-1.2,LE-1.3	Unit-1.0 Generalized Measurement System. 1.1, 1.2, 1.3,1.4	As mentioned in relevant page numbers.
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-2 Use control system for the given industrial application.	SO.2.1,SO.2.2,SO2.3 SO2.4	LE-2.1,LE-2.2	Unit-2.0 Introduction to Control system 2.1, 2.2 ,2.3 ,2.4, 2.5	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-3 Use relevant instruments for displacement and speed measurement	SO.3.1,SO3.2,SO.3.3 SO3.4	LE-3.1,LE -3.2,LLE-3.3 LE-3.4	Unit-3.0 Displacement and speed measurement 3.1, 3.2, 3.3	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-4 Use temperature measuring instruments**.**	SO4.1,SO4.2	LE4.1,LE4.2,LE4.3	Unit-4.0 Temperature measurements- 4.1 4.2, 4.3, 4.4	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-5 Use flow measurements and pressure measurements instruments.Storage Oscilloscope for measurements.	SO5.1,SO5.2,SO5.3 SO5.4	LE5.1,LE5.2,LE5.3,LE5.4 LE5.5	Unit-5.0 Flow and Pressure measurements 5.1, 5.2 ,5.3,	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-6 Use strain measuring instruments to measure strain.	SO6.1,SO6.2	LE6.1,LE6.2	UNIT 6.0 Strain measurements 6.1,6.2,6.3	

A) Course Code : 2037474(037)

B) Course Title : Fluid Mechanics and Machinery

C) Pre- requisite Course Code and Title :

D) Rationale :

In Engineering field the knowledge of fluid properties, fluid flow, hydraulics and pneumatics is essential because in industries the machines and equipments are operated by fluid power. The mechanical engineer has to frequently deal with the devices like turbines and pumps and so the basic knowledge of fluids and its flow characteristics is a prerequisite to understand the working of various fluid handling devices and to understand their working performance under different situations. This subject will impart the essential skills and knowledge of fluid properties, hydraulics and pneumatics which will require to tackle the day to day situations faced in the industry.

E) Course Outcomes:

CO-1 Analyze various fluid characteristics.

CO-2 Apply the fluid flow energy equations to real field situations.

CO-3 Calculate various losses in flow through pipes

CO-4 Select relevant turbine as per the situation.

CO-5 Select a relevant pump as per the requirement

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) (L+T+P/2)
1	Mechanical Engineering	2037474(037)	Fluid Mechanics and Machinery	2	-	1	3
2	Mechanical Engineering	2037464(037)	Fluid Mechanics and Machinery(Lab)	-	2	-	

Legend: L: Classroom Instruction (Includes different instructional strategies i.e. Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) T- Tutorial includes Sessional Work (SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credits

Note: SW & SL have to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Mechanical Engineering	2037474(037)	Fluid Mechanics and machinery	70	20	30	-	-	120
2	Mechanical Engineering	2037464(037)	Fluid Mechanics and machinery(Lab)	-	-	-	30	50	80

Note i. Separate passing is must for TA component of Progressive Assessment, both for theory and practical.
ii. Separate passing is must for End Semester Exam(Theory) and End Semester Exam(Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (P), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Analyze various fluid characteristics.

(Approx. Hrs: L+P+T=24)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Apply the continuity equation to given real system. SO1.2 Explain procedure to measure pressure using different types of manometer and different types of pressure gauge. SO1.3 Calculate the Hydrostatic forces in the given situation as per the given data. SO1.4 Calculate pressure head for a given condition. SO1.5 Calculate centre	LE1.1 Use viscometer to determine the viscosity of a given liquid. LE1.2 Measure the rise of liquid level using capillary action in capillary tube. LE1.3 Determine the specific gravity of any given fluid. LE1.4 Use manometer/ incline manometer to measure the pressure of the given fluid. LE1.5 Determine the meta-centric height of ship model.	**Unit-1.0 Fluid properties and Fluid Pressure** 1.1 Introduction and classification of fluid. 1.2 Fluid properties- Density, Specific gravity, specific weight, specific volume, Dynamic & Kinematic viscosity, Surface tension, Capillarity, Vapour pressure, Compressibility, Bulk modulus. 1.3 Types of fluids: Ideal, Real, Newtonion, Non-Newtonion fluid 1.4 Continuity equation and simple numerical problems based on it. 1.5 Pressure, Fluid pressure, pressure head, Pressure Intensity, Concept of	• Measurement of density • Pressure measurement using bourdon gauge. • Dead weight pressure gauge

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
of pressure and total pressure of regular immersed bodies. SO1.6 Calculate Metacentric height and Centre of buoyancy of the given floating body.		absolute Vacuum, Gauge Pressure, Atmospheric Pressure, Absolute Pressure, 1.6 Pressure measurement- Manometer, U- tube manometer, Incline manometer, Inverted U manometer, Piezometer. 1.7 Concept of Total pressure, Centre of pressure, Pascal's law, Hydrostatic forces on plane and curved surface immersed in liquid and simple problems on it, 1.8 Metacenter	

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Write the applications of compressible and incompressible fluid
ii. Signify the importance of fluid property 'surface tension' in engineering applications.
iii. Find the difference in viscosity of various grades of oil without using any apparatus.
iv. Describe the situations where viscosity is a undesirable property.
v. Explain the criteria of selecting manometric fluid.
vi. Identify any 5 cases of body floating/submerged in fluids and determine:
   (a) Center of pressure,
   (b) Hydrostatic forces, and
   (c) Metacenter.

b. Mini Project:

i. Collect 05 no. of industrial fluids and five general fluids from the market and find out their specific gravity, Density, specific weight etc, and write a report.
ii. Visit nearby industry/power plant and prepare a list of pressure measurement devices used along with their specifications.

CO- 2 Apply the fluid flow energy equations to real field situations.

(Approx. Hrs: L+P+T=8**)**

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Identify the various forms of energy related to given fluid flow. SO2.2 Calculate the total energy in a given fluid. SO2.3 Solve numerical problems on energy equations.	LE-2.1 Experimentally justify Bernoulli's theorem for a viscous and incompressible fluid. LE-2.2 Determine the pressure energy, kinetic energy and datum energy of a given flowing fluid.	**Unit-2.0. Fluid flow energy equation** 2.1 Various forms of energies applicable to fluid flow – Potential energy, Kinetic energy, Pressure energy, Total energy 2.2 Concept of datum pressure, Velocity and total head of fluid in motion. 2.3 Energy equation- Steady flow energy equation and derivation of Bernoulli Theorem and its assumption and practical application. Simple numerical problems on Bernoulli equation.	• Navier Stoke's equation and its application

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Explain the forms of energy present in water flowing in a river/stream. Compare it with that present in water stored in a pond.
ii. Write the importance of choosing correct datum for measuring various energy head.
iii. Relate the pressure energy and kinetic energy.
iv. Why does water has the property of surface tension. Explain?

b Mini project:-

i. Perform an experiment to understand the concepts of surface tension, cohesion, and adhesion.

CO-3 Calculate various losses in flow through pipes

(Approx. Hrs: **L+P+T=**17)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.1 Identify types of fluid flow in a given situation. SO3.2 Calculate the loss of head in fluid flow through pipes in a given situation as per	LE3.1 Determine discharge through a given pipe using orifice meter, pitot tube and venturimeter. LE3.2 Determine Cc, Cd, Cv for different	**Unit-3.0 Flow through pipes** 3.1 Fluid flow- Steady, unsteady, uniform, non uniform, laminar and turbulent flow 3.2 Flow measurement- definition and types of	• Rotational and irrotational flow

Session Outcomes	Laboratory Instruction	Class room Instruction	Self Learning
the given data. SO3.3 Explain the effect of water hammer due to the sudden change in velocity and pressure of the given fluid. SO3.4 Explain various losses in flow through pipes, fittings and valves. SO3.5 Solve numerical based on continuity equation, laws of friction and losses in flow through pipes.	types of orifices. LE3.3 Determine loss of head due to a. Sudden enlargement b. Sudden contraction c. Friction in pipes LE3.4 Determine the different types of flow Patterns by Reynolds's experiment. LE3.5 Measure the flow characteristic of given flowing fluids	orifices, Vena contraction, coefficient of contraction, Experimental determination of C_c, C_d , C_v 3.3 Construction, working, application and simple problem on – Venturimeter, orifice meter, pitot tube, Nozzle. 3.4 Viscous flow-Concept of viscosity of fluids, Reynolds number and its criteria for plate and pipes, Darcy -Weisbatch equation, loss of head due to friction in pipe , Hagen- Poiseuille formula 3.5 Flow through pipes- Pipes in series, Pipes in parallel, Head losses- various types of minor and major energy loss occur in fluid flow through pipes. H.G.L. and T.E.L., surge tank, water hammer and its effects.	

SW-3 Suggested Sessional Work (SW):

a. Assignments:

i. Identify the nature of flow in following case:
   (a) Flow of water in a river during heavy flood
   (b) Flow of water through a canal in summer
   (c) Flow of water through a nozzle

ii. Verify the relation $C_d = C_v \cdot C_c$

b. Mini Project:

i. Visit to nearby water filter plant and sketch the pipe arrangement for water supply. Also collect the specification.

ii. Construct a pipe arrangement in series and parallel and compare the both by discharge (Q), total head loss

CO-4 Select relevant turbine as per the situation.

(Approx. Hrs: L+P+T=17)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Select suitable turbine for a given site/situation with justification. SO4.2 Describe the construction and working of the given water turbines. SO4.3 Describe the construction and working of the given draft tube. SO4.4 Calculate the work done, power, efficiency of turbines. SO4.5 Calculate the force exerted by impact of jet plate in stationary and moving blades	LE4.1 Investigate the reaction force produced by the impact of a jet of water on to various target vanes LE4.2 Plot the characteristic curves of a. Pelton wheel b. Francis Turbine c. Kaplan turbine	**Unit-4.0 Hydraulic Turbine** 4.1 Classification of hydraulic turbines 4.2 Functions and working principle of Impulse and reaction turbine 4.3 Comparison of impulse and reaction turbine 4.4 Construction and working principle of Pelton wheel, Francis and Kaplan turbine 4.5 Selection of turbine on the basis of head and discharge, 4.6 Draft tube – types, constructions, and benefit of draft tubes 4.7 Calculation of work done, power, efficiency of turbines 4.8 Safety precaution on turbines 4.9 Impact of jet on flat and curved plate in stationary and moving blades.	• Bulb turbine

SW-4 Suggested Sessional Work (SW):

a Assignments:

i. Visit the nearby hydel power station and collect the specification of turbine being used.
ii. List the criteria of classification of water turbine.
iii. List the Mini, Micro, and Medium capacity hydro plants located in Chhattisgarh and Mention their Key features.

b Mini Projects:

i. Prepare a model of hydraulic power station which you have visited and shows its main elements along with their specification.

CO-5 Select a relevant pump as per the requirement.

(Approx. Hrs: **L+P+T=14**)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Describes construction and working of the given pump. SO5.2 Select suitable Pump for a given application with justification. SO5.3 Explain construction and working of the given reciprocating pump.	LE5.1 Determine the power required to drive the given reciprocating pump. LE5.2 Determine the performance characteristics of: a. Centrifugal pump b. Reciprocating Pump	**Unit 5.0 Pumps** 5.1 Centrifugal pumps- Construction, working principle and application of centrifugal pump. Total head of pump, Classification of centrifugal pump, impellers, casing, stages, priming and cavitations. 5.2 Reciprocating pumps- Construction, working principle and application of reciprocating pump, single acting and double acting, slip, negative slip, use of air vessels, Comparison of centrifugal and reciprocating pump. 5.3 Submersible pump- Construction, working principle and application of submersible pump.	Double stage centrifugal pumps, net positive suction head

SW-5 Suggested Sessional Work (SW):

a Assignments:

i. List the criteria of classification of water pumps.
ii. Compare the centrifugal and submersible pump.
iii. Disadvantages of priming in centrifugal pump.
iv. Write notes on cavitations phenomena of centrifugal pumps.

b Mini project:

i. Assemble and disassemble the domestic cooler pump and analyze its working and also list its main elements.
ii. Visit to nearby water filter plant/ industry and prepare a report on types of pump used along with their detailed specification.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESE of Classroom Instruction):

Unit Number	Unit Title	Marks Distribution			Total Marks
		R	U	A	
I.	Fluid Properties and Fluid Pressure	4	6	10	20
II.	Fluid Flow Energy Equation	2	2	8	12
III.	Flow Through Pipes	2	2	8	12
IV.	Hydraulic Turbines	2	4	8	14
V.	Pumps	2	2	8	12
	Total	**12**	**12**	**46**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Use viscometer to determine the viscosity of a given liquid.	15	10	5
LE1.2	Measure the rise of liquid level using capillary action in capillary tube.	15	10	5
LE 1.3	Determine the specific gravity of any given fluid.	15	10	5
LE1.4	Use manometer/ incline manometer to measure the pressure of the given fluid.	15	10	5
LE1.5	Determine the meta-centric height of ship model.	15	10	5
LE2.1	Experimentally justify Bernoulli's theorem for a viscous and incompressible fluid.	15	10	5
LE2.2	Determine the pressure energy, kinetic energy and datum energy of a given flowing fluid.	15	10	5
LE3.1	Determine discharge through a given pipe using orifice meter, Pitot tube and Venturimeter.	15	10	5
LE3.2	Determine Cc, Cd, Cv for different types of orifices.	15	10	5
LE3.3	Determine loss of head due to (a) Sudden enlargement (b) Sudden contraction (c) Friction in pipes	15	10	5
LE 3.4	Determine the different types of flow Patterns by Reynolds's experiment.	15	10	5
LE 3.5	Measure the flow characteristic of given flowing fluids.	15	10	5
LE4.1	Investigate the reaction force produced by the impact of a jet of water on to various target vanes	15	10	5

LE4.2	Plot the characteristic curves of (a) Pelton wheel (b) Francis Turbine (c) Kaplan turbine	15	10	5
LE5.1	Determine the power required to drive the given reciprocating pump.	15	10	5
LE5.2	Determine the performance characteristics of: (a) Centrifugal pump (b) Reciprocating Pump	15	10	5

*Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practicals.
Experiments marked with it may not be given for ESE. However viva-voce questions related to '#', may be integrated with other experiments during ESE.
Legend: PRA: Process Assessment, PDA: Product Assessment
Note: Only one experiment has to be performed at the end semester examination of 30 Marks as per assessment scheme

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Group Discussion
4. Industrial visits
5. Industrial Training
6. Field Trips
7. Portfolio Based Learning
8. Demonstration
9. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)

L) Suggested Learning Resources:

(a) Books :

S. No.	Title	Author	Publisher	Edition & Year
1.	Hydraulics, Fluid Mechanics and Hydraulic Machines.	Khurmi R.S. Khurmi N.	S. Chand and Co. Ltd., New Delhi • ISBN-10: 8121901626 • ISBN-13: 978-8121901628	15th or latest Revised edition, 2014
2.	Fluid mechanics and hydraulic machines.	Bansal R.K.	Laxami Publication, New Delhi • ISBN-10: 8131808157 • ISBN-13: 978-8131808153	Tenth or latest edition,2018
3.	Fluid mechanics and hydraulic machines	Rajput R.K.	S. Chand and Co. Ltd., New Delhi • ISBN-10: 8121916666 • ISBN-13: 978-8121916660	3rd or latest Rev. Edition, 2006

4.	Hydraulics & Fluid Mechanics Including Hydraulics	Modi P.N. Seth S.M.	Standard Book House U/o Rajsons Publications Pvt Ltd, New Delhi • ISBN-10: 8189401262 • ISBN-13: 978-8189401269	20th or latest edition, 2017
5.	Textbook of Fluid Mechanics and Hydraulic Machines	Pati Sukumar	McGraw Hill Education New Delhi •ISBN-10: 1259006239 •ISBN-13: 978-1259006234	Latest edition, 2017
6.	Introduction to Fluid Mechanics and Fluid Machines	S K Som & G Biswas	Mc Graw Hill Publication ISBN-13:978-0-07-066762-4 ISBN-10:0-07-066762-4	Revised Second Edition
7.	Fluid Mechanics and Hydraulic Machines (Taral Yantiriki awm Drav Chalit Machines)	S S L Patel	University Book House, Jaipur ISBN-9788181982292	Latest edition, 2013

(b) Open source software and website address:

1. Nptel course- **http://nptel.ac.in/courses/112105171/**
2. fluid and their propertie- https://www.youtube.com/results?search_query=fluid+and+their+propertie
3. Continuity equation-- https://www.youtube.com/results?search_query=Continuity+equation+
4. Pressure measurement- https://www.youtube.com/results?search_query=Pressure+measure
5. Pascal's law - https://www.youtube.com/results?search_query=Pascal%E2%80%99s+law
6. Metacenter-- https://www.youtube.com/results?search_query=2.4%09Metacenter
7. buoyancy - https://www.youtube.com/results?search_query=buoyancy
8. Fluid flow energy equation - https://www.youtube.com/results?search_query=Fluid+flow+energy+equation
9. Fluid flow - https://www.youtube.com/results?search_query=Fluid+flow+
10. Flow measurement- https://www.youtube.com/results?search_query=2.%09Flow+measurement
11. Venturimeter- https://www.youtube.com/results?search_query=Venturimeter
12. Classification of hydraulic turbines- https://www.youtube.com/results?search_query=5.1%09Classification+of+hydraulic+turbines+
13. Francis Turbine - https://www.youtube.com/results?search_query=%29+Francis+Turbine+
14. Kaplan turbine- https://www.youtube.com/results?search_query=Kaplan+turbine
15. Centrifugal pumps- https://www.youtube.com/results?search_query=Centrifugal+pumps-+
16. Reciprocating pumps- https://www.youtube.com/results?search_query=Reciprocating+pumps-
17. Submersible pump https://www.youtube.com/results?search_query=1.%09Submersible+pump++animation

(c) Others:

1 Learning Packages.
2 Lab Manuals.
3 Manufacturers' Manual
4 Users' Guide

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	Red wood viscometer	Electrically Heated with Digital temperature controller cum indicator	LE1.1
2	Capillary tube	Capillary tube of different diameters, beaker/petri dish,	LE1.2
3	Beaker, Pipette, Electronic balance, Thermometer	The Electronic Digital Balance 2kg x 0.5 gram, Beaker 500 ml, Pipette 50 ml , digital thermometer	LE1.3
4	manometer	Glass tube 50 mm, Complete set up for pressure measurement, wall or stand mounted, Mercury as manometeric fluid	LE2.1
5	Differential Manometer	Glass tube 50 mm, Complete set up for demonstration of pressure measurement, wall or stand mounted, Mercury as manometeric fluid	LE2.1
6	Venturimeter setup for measurement of discharge	Complete set up for measurement of discharge including power supply, water tank, and all accessories and instruments.	LE4.1
7	Orificemeter setup for measurement of discharge	Complete set up for measurement of discharge including power supply, water tank, and all accessories and instruments.	LE4.1
8	Setup for Bernoulli's Theorem	Complete set up for to verify the Bernoulli's theorem including power supply, water tank, and all accessories and instruments.	LE3.1
9	Setup for Friction losses through Pipes	Complete set up for friction losses including power supply, water tank, and all accessories and instruments.	LE4.3
10	Setup for losses due to enlargement & contraction in pipes	Complete set up of enlarge and contraction pipe, including power supply, water tank, and all accessories and instruments.	LE4.3
11	Reciprocating Pump test rig	Complete setup to test performance parameter of reciprocating pump up to 5 HP	LE6.1 LE6.2
12	Centrifugal Pump test rig	Complete setup to test performance parameter of Centrifugal Pump up to 5 HP	LE6.2
13	Pelton wheel test rig	Complete setup to test performance parameter and characteristics	LE5.2
14	Kaplan turbine test rig	Complete setup to test performance parameter and characteristics	LE5.2
15	Francis turbine test rig	Complete setup to test performance parameter and characteristics	LE5.2
16	Impact of jet apparatus	Complete set up including Sump Tank, Measuring tank, nozzles and vanes.	LE5.1

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
17	Reynolds Apparatus	Complete setup consisting of Borosilicate Glass tube, Stainless steel Dye vessel, Copper/Stainless Steel Capillary Tube, Water Tank, arrangement for flow measurement, stop watch and power supply	LE4.4
18	Metacentric height apparatus	Complete setup for Metacentric height calculation including tank , ship model	LE2.2

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1 Modern Software Usage	PSO-2 Equipment and Instruments	PSO-3 Mechanical Engineering Processes
CO-1 Analyze various fluid characteristics	3	3	3	-	-	-	2	3	2	3	2	2	3
CO-2 **Apply the fluid flow energy equations to real field situations**	3	3	3	-	-	-	2	3	2	3	2	2	3
CO-3 Calculate various losses in flow through pipes	3	3	3	-	-	1	2	3	2	3	2	2	3
CO-4 Select relevant turbine as per the situation	3	3	3	-	1	2	2	3	2	3	2	2	3
CO-5 Select a relevant pump as per the requirement	3	3	3	-	1	2	2	3	2	3	2	2	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No. & Titles	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-1,2,3,8,9,10 PSO-1,2,3	CO-1 Analyze various fluid characteristics.	SO1.1,SO1.2 SO1.3,SO1.4 SO1.5,SO1.6	LE1.1,LE1.2 LE1.3,LE1.4 LE1.5	Unit-1.0 Fluid properties and Fluid Pressure 1.1 , 1.2, 1.3, 1.4, 1.5, 1.6,1.7,1.8	As mentioned in relevant pages
PO-1,2,3,8,9,10 PSO-1,2,3	CO-2 Apply the fluid flow energy equations to real field situations	SO.2.1,SO.2.2 SO2.3	LE. 2.1, LE. 2.2	Unit-2.0 Fluid flow energy equation 2.1, 2.2, 2.3	
PO-1,2,3,6,7, 8,9,10 PSO-1,2,3	CO-3 Calculate various losses in flow through pipes	SO.3.1,SO3.2 SO3.3,SO.3.4 SO3.5	LE3.1,LE3.2 LE3.3,LE3.4 LE3.5	Unit-3.0 Flow through pipes 3.1, 3.2, 3.3, 3.4,3.5	
PO-1,2,3,5,6,7, 8,9,10 PSO-1,2,3	CO-4 Select relevant turbine as per the situation.	SO4.1,SO4.2 SO4.3,SO4.4 SO4.5	LE4.1,LE4.2	Unit-4.0 Hydraulic Turbine 4.1, 4.2, 4.3, 4,4.5,4.6,4.7,4.8,4.9	
PO-1,2,3,5,6,7, 8,9,10 PSO-1,2,3	CO-5 Select a relevant pump as per the requirement	SO5.1,SO5.2 SO5.3	LE5.1,LE5.2	Unit-5.0 Pumps 5.1,5.2,5.3	

A) Course Code : 2037475(037)
B) Course Title : Engineering Metrology
C) Pre- requisite Course Code and Title :
D) Rationale :

In today's high-tech world dimensional control of products has become very important to ensure the quality and reliability of the products being manufactured. Unless the manufactured parts are accurately measured, assurance of quality cannot be given. In this context, the course deals with the basic principles of dimensional measuring instruments and precision measurement techniques. The Mechanical Engineer Diploma holder should understand, select and use various measuring instruments as he often comes across measuring different parameters of machined components and the appropriate fitment of interchangeable components in the assemblies. The knowledge of the subject also forms the basis for the design of mechanical measurement systems, design and drawing of mechanical components.

E) Course Outcomes:

CO-1 Select the suitable inspection process for engineering situations/applications and correlate the cost of manufacturing with accuracy.

CO-2 Use appropriate instrument(s) for linear measurements.

CO-3 Use relevant instruments for angular measurements.

CO-4 Use relevant geometric tolerance and surface roughness instruments for dimensional applications.

CO-5 Use relevant instruments for screw thread measurements and gear measurements.

CO-6 Use relevant comparators and limit gauges for various situations/applications.

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits (C) L+T+(P/2)
1.	Mechanical Engineering	2037475(037)	Engineering Metrology	2	-	1	3
2.	Mechanical Engineering	2037465(037)	Engineering Metrology(Lab)	-	2	-	1

Legend: L: Classroom Instruction (Includes different instructional strategies i.e. Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) T- Tutorial includes Sessional Work(SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credits

Note: SW and SL have to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1.	Mechanical Engineering	2037475(037)	Engineering Metrology	70	20	30	-	-	120
2.	Mechanical Engineering	2037465(037)	Engineering Metrology(Lab)	-	-	-	30	50	80

Note: i. Separate passing is must for TA component of Progressive Assessment, both for theory and practical.
ii. Separate passing is must for End Semester Exam (Theory) and End Semester Exam(Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (PS), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Select the suitable inspection process for engineering situations/applications and correlate the cost of manufacturing with accuracy.

(Approx. Hrs: L+P+T=8)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Select suitable inspection process for the given component with justification. SO1.2 Explain the importance of metrology as a means for achieving quality. SO1.3 Relate cost and accuracy for the given inspection activity. SO1.4 Identify the elements of measuring system and explain the need and importance of standards.	LE1.1 Given the industrial situations, suggest the type of inspection applicable to each situation. LE1.2 Given the situations, state where accuracy is necessary and where precision is necessary.	**Unit-1.0 Introduction** 1.1 Inspection, its objective and purpose, types of inspection – raw material inspection, in process inspection, final inspection, Methods of Inspection - centralized and decentralized inspection, their advantages, disadvantages and applications, Inspection report. 1.2 Metrology: Correlation of inspection and metrology, definition of metrology and its importance in industrial inspection, meaning of specification, Interchangeability and selective assembly, 1.3 Accuracy and Precision, their need in industrial measurement, relationship between cost and accuracy, Errors – systematic and random 1.4 Elements of measuring systems – standard, work piece, instruments, person and environment, Standard, its importance material standard and wavelength standard, classification of standards – primary, secondary, tertiary and working standards.	• Standardizing organizations – National Physics Laboratory, International Organisation of Weight and Measures

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i Identify at least five situations in our daily life where we use inspection.
ii Explain the effect of absence of inspection in any industry citing suitable examples.
iii List the items to be included in an inspection report.
iv List at least five factors that affect each of the elements of the measuring system.
v Explain why the person carrying out the inspection should not establish his own standards?

b. Mini Project:

i Visit nearby market and collect the specifications of given industrial products. What will happen if products are purchased without specifications?

c. Other Activities (Specify):

i Visit nearby industry to observe various inspection methods and prepare a detailed report about the type of inspection used.

CO-2 Use suitable instrument(s) for linear measurements.

(Approx. Hrs: L+P+T=14)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Classify different linear measurement instruments. SO2.2 Select suitable direct/indirect measuring instrument(s) for the given situation with justification. SO2.3 Explain the procedure of direct/indirect measurement for the given situation with justification. SO2.4 Explain the procedure of using dial gauge for checking linear features of the given component with justification. SO2.5 Explain the procedure of using slip gauges for measuring the given job.	LE2.1 Measure the linear dimensions (length, diameter – outside & inside) of the given job using vernier caliper. LE2.2 Measure the diameter – outside & inside) of a given job using micrometer. LE2.3 Measure the height of the given object using vernier height gauge. LE2.4 Measure the depth of a given object using Depth gauge. LE2.5 Check the parallelism and perpendicularity of a machine tool using dial gauge. LE2.6 Set a job on lathe using dial gauge. LE2.7 Set the adjustable snap gauge Go end and No-Go end for a give dimension using slip gauges combination.	**Unit-2.0 Linear Measurement** 2.1 Standards of length – Line and End standards, their characteristics and applications, Datum planes in dimension measurement – Surface plate, V-block. 2.2 Classification of linear measurement instruments – direct and indirect with examples, Direct measuring instruments: i Vernier caliper, ii Micrometer – outside, inside and depth iii Vernier height gauge iv Depth gauge construction working, handling, specifications, applications, precautions and errors of each 2.3 Indirect measuring instruments: Telescopic gauges, small hole gauges –their construction, working,	• Steel rule, Calipers • Interferometer

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		specifications, applications, precautions and errors. 2.4 Dial Gauge: classification as per IS: 2092-1962, schematic diagram, function of parts, working principle, accuracy, applications and precautions. 2.5 Slip gauge – Classification as per IS: 2984-1966, their accuracy, applications, selection of gauge blocks, wringing, handling and precautions.	

SW-2 Suggested Sessional Work (SW) :

a. Assignments:

i Compare line and end standards and give at least five examples of instruments based on each of these.

ii Compare vernier caliper and micrometer on the basis of accuracy, measuring range, advantages and limitations.

iii For a given dimension and given set of slip gauge, suggest the gauge block piles (at least 5 problems)

b. Mini Project:

i From a given drawing or actual component, find the linear variables to be measured, suggest suitable instrument to measure them and state the reason for choice.

ii Measure the same linear dimensions of a given job with vernier caliper and micrometer and compare them on the basis of accuracy, time of inspection, cost of inspection and error.

c. Other Activities (Specify):

i Prepare a power point presentation on applications of linear measuring instruments.

CO- 3 Use suitable instruments for angular measurements.

(Approx. Hrs: **L+P+T=15**)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.1 Explain the procedure to use optical bevel protractor and universal bevel protractor to measure the given angle.	LE3.1 Measure given angle of a component using Optical bevel protractor and Universal bevel protractor. LE3.2 Set the Sine bar to a given known angle. LE3.3 Measure the angle of	**Unit-3.0 Angular measurements** 3.1 Need for angle measurement, Direct angle measurement: i Optical Bevel Protractor ii Universal Bevel protractor	• Clinometer and its applications • Digital and Laser Autocollimator

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.2 Explain procedure to measure the given angle using angle gauges. SO3.3 Explain procedure to measure the given angle using Sine bar. SO3.4 Explain procedure to use spirit level to check the given angle. SO3.5 Explain procedure to use autocollimator to measure the angle(s) of a component. SO3.6 Explain procedure to use angle dekkar to measure the angle of a component.	taper of a given component using Sine bar. LE3.4 Measure the angle of a given component with Angle Dekkor.	their construction, working, handling, specifications, applications, precautions. 3.2 Indirect angle measurement: i Angle gauges – sets, , handling, method of combining, selection of angle gauge blocks for a given angle. ii Sine bar – working principle, types as per IS:5979-1970, specifications, handling, measuring known and unknown angles. iii Spirit level – working principle, sensitivity and factors affecting it, handling, applications, . iv Autocollimator – working principle, construction, handling, applications. v Angle Dekkor – working principle, construction, handling, applications.	

SW-3 Suggested Sessional Work (SW) :

a. Assignments:

i Explain the method of finding least count of universal bevel protractor.

ii For a given angle and given set of angle gauges, select angle gauge blocks (at least 3 problems).

iii For measuring the angle of a given component select suitable angle measuring instrument and justify your choice.

b. Mini Project:

i Prepare a chart showing the comparison of various angle measuring instruments on the basis of accuracy, measuring range, advantages and limitations.

ii Measure the same angular dimensions of a given job with universal bevel protractor and angle gauge and interpret the results.

c. Other Activities (Specify):

i Prepare a power point presentation on various angle measuring instruments.

ii Conduct a market survey for angle measuring instruments available in the local market and chart out their specifications.

CO-4 Use suitable geometric tolerance and surface roughness instruments for dimensional applications.

(Approx. Hrs: **L+P+T=14**)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Select instrument (s) to measure straightness, flatness, squareness and roundness of the given job/situation with justification. SO4.2 Explain the various terms associated with assessment of surface roughness. SO4.3 Select the surface roughness instruments for the given job with justification. SO4.4 Identify the conditions of surface for the given surface roughness value for different machining processes recommended by IS:3073.	LE4.1 Check the straightness of the given job with straight edge method and Wedge method. LE4.2 Check the straightness of the given job using precision level. LE4.3 Check the straightness of the given job using autocollimator. LE4.4 Check the flatness of the given job using precision level. LE4.5 Check the flatness of the given job using autocollimator. LE4.6 Check the squareness of a given job using indicator method or Engineer's squareness tester. LE4.7 Check the roundness of the given job using V block and dial indicator. LE4.8 Using any one direct measuring instrument check the conformity or non-conformity of the given three test specimen with values of roughness recommended by IS:3073.	**Unit 4.0 Measurement of Geometric Tolerances and Surface Roughness** 4.1 Concept of straightness, flatness, squareness and roundness, importance of their measurement. 4.2 Measurement of Straightness: Straight edge method (Light gap and feeler gauge method), Wedge method, Precision level method and Autocollimator method Their principle, instruments required for each method, precautions, limitations, applicability i.e., type of job/situation where each of methods is suitable and accuracy of each method. 4.3 Measurement of flatness: High spot method, Precision level method, Autocollimator method Their principle, instruments required for each method, precautions, limitations, applicability i.e., type of job/situation where each of methods is suitable and accuracy of each method. 4.4 Measurement of Squareness: Indicator method, Engineer's square tester, Autocollimator method Their principle, instruments required for each, method, precautions, limitations, applicability *i.e.,* type of job/situation where each of methods is suitable	• Measurement of radius, concentricity, run out. • Other methods of measurement of surface roughness

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		and accuracy of each method. 4.5 Measurement of Roundness: V block and Dial indicator method, principle, instruments required, precautions, and limitations. 4.6 Assessment of surface roughness: i Terminology associated with assessment of surface roughness (as per IS: 3073 – 1967) – Surface roughness, primary texture (roughness), secondary texture (waviness), real surface, geometrical surface, effective surface, real profile, geometrical profile, effective profile, reference line, lay, traversing length, sampling length, spacing of irregularities, mean line of profile, centre line of profile. ii 'M' and 'E' system of assessment of surface roughness, their merits and demerits, reasons for adoption of 'M' system, iii Basic units of indicating surface roughness – C.L.A. value, R.M.S. value, ten point height of irregularity, their graphical and mathematical interpretation iv Measurement of surface roughness (a) Comparison method - touch inspection, visual inspection, scratch inspection, microscopic inspection, their	

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		applications , limitations (b) Direct measurement – Stylus based instrument: Tomlinson surface meter, Taylor-Hobson Talysurf, Profilometer 4.4 Relationship of Machining processes and surface texture and their representation.	

SW-4 Suggested Sessional Work (SW) :

a. Assignments:

i Explain why measurement of straightness, flatness and squareness is important in engineering and prepare a list of engineering applications where these are required?

ii Compare the accuracy of different methods of straightness measurement for a given job.

iii Given the graph of surface variations as obtained in LE 4.4 and LE 4.5, interpret the same to compare both the methods on the basis of accuracy.

iv Mention the reasons which cause primary texture and secondary texture in a machine component.

v Differentiate the three basic units of indicating surface roughness, if represented on same profile, based on ease of measurement and reliability of assessment of surface roughness.

b. Mini Project:

i Prepare an exhaustive list of representative components/engineering applications where measurement of straightness, flatness, squareness and roundness would be relevant.

ii Compare the various methods of surface roughness assessment on the basis of ease, accuracy, their relative advantages and limitations.

iii Given the surface roughness values for different machining processes, identify the qualitative aspects of conditions of surface.

c. Other Activities (Specify):

i Prepare a power point presentation on applications of Stylus system of measurements.

CO-5 Use suitable instruments for screw thread measurements and gear measurements.

(Approx. Hrs: L+P+T=15)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Sketch and Identify the various elements of a screw thread. SO5.2 Select measuring instrument/metod	LE5.1 Measure the effective diameter of a given screw thread using screw thread micrometer. LE5.2 Measure the pitch of a given screw thread using screw pitch	**Unit 5.0 Screw Thread Measurements and Gear Measurements** 5.1 Thread nomenclature, Various types of threads, Errors in screw threads: Error in Pitch	• Two and Three wire method of screw thread measurement.

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
for measuring the given external or internal screw thread element with justification. SO5.3 Explain the procedure of measurement of external or internal screw thread element using the given instrument. SO5.4 Sketch and Identify various elements of the given gear. SO5.5 Select suitable measuring instrument/method for measuring given gear element with justification.	gauge. LE5.3 Measure the major diameter, minor diameter, pitch and included angle using toolmaker's microscope. LE5.4 Measure the gear tooth thickness using Gear tooth vernier caliper. LE5.5 Check the gear tooth form using toolmaker's microscope.	(Progressive and periodic), effective diameter, major diameter, minor diameter and angle or form. 5.2 Methods of measuring external screw thread elements: i Pitch – Thread pitch gauge, microscope method, Pitch measuring machine ii Effective diameter – Thread micrometer, two and three wire method iii Minor diameter – Micrometer with two V – shaped hard steel pieces iv Major diameter – Micrometer v Angle or Form – Tool room projection Procedure of each method, precautions to be taken, advantages and limitations. 5.3 Methods of internal thread measurement: i Core diameter – Using Wedge parallel and micrometer ii Effective diameter - Using optical comparator iii Thread Form – Using thread cast method, materials used for casting – plaster of Paris, Sulphur, Dental wax Procedure of each method, precautions to be taken, advantages and limitations. 5.4 Gear Measurement: Terminology associated with gear measurements, recall types of gears with	

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		their sketches, Spur gear nomenclature, need of gear measurement, Gear elements requiring measurement – gear tooth form, gear tooth thickness, pitch, eccentricity. 5.5 Measurement of gear elements: i Gear tooth form – Principle of measurement, Use of Tool room microscope, Use of David Brown gear tooth form testing machine. ii Gear tooth thickness – Principle of measurement – Chordal thickness and Constant Chord, Use of Gear tooth vernier caliper. iii Pitch – Principle of pitch measurement, Use of Parkson gear tester. iv Eccentricity – Purpose and principle of measurement.	

SW-5 Suggested Sessional Work (SW) :

a. Assignments:

i Mention the characteristics which distinguish between the different types of screw threads.
ii Explain the effect of pitch errors on the functioning of screw threads.
iii Compare the different methods of pitch measurement on the basis of ease, accuracy, their relative advantages and limitations.
iv Explain the effect of inaccurate gear element on the performance of gear operation.
v Compare the chordal thickness and constant chord method of gear tooth thickness measurement on the basis of ease and principle.

b. Mini Project:

i Collect and prepare a list of different types of screw threads commercially available.
ii Sketch the nomenclature of a screw thread on A3 size drawing sheet.
iii Sketch the nomenclature of a gear on A3 size drawing sheet.
iv Collect different types of gears and list out their applications.

c. Other Activities (Specify):

i Prepare a power point presentation on screw thread/gear errors and their effect on the performance of the screw thread/gear.

CO-6 Use suitable comparators and limit gauges for various situations/applications.

(Approx. Hrs: L+P+T=14)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO6.1 Select a comparator for a given situation with justification. SO6.2 Select limit gauge for the given situation with justification. SO6.3 Calculate the gauge dimensions for the given set of data.	LE6.1 Determine the fluctuation of energy of two stroke and four stroke petrol engines and justify the size of flywheels. LE6.2 Use dial indicator as mechanical comparator to inspect given components. LE6.3 Use limit gauges to check given dimensions.	**Unit 6.0 Comparators and Limit Gauges** 6.1 Comparators: Definition, working principle, basic requirements of a good comparator, applications. 6.2 Types of Comparators – Mechanical, Electrical, Optical and Pneumatic Their working, application, advantages and limitations, selection for given specific work/component . 6.3 Limit Gauges: Recall the terminology associated with limits, fits and tolerances, Define gauging, its need and difference with measuring, classification of gauges – according to use, according to form, according to construction, according to specific use. 6.4 Fixed size gauges – Plug, ring, snap and thread gauges, their sketches, applications, Go and Not Go ends of a limit gauge, their purpose and identification. 6.5 Taylor's principle, maximum and minimum metal conditions and their correlation with Go and Not Go gauge, working tolerance, gauge tolerance, wear allowance, calculation of gauge dimensions for a given set of data.	• Gauge materials

SW-6 Suggested Sessional Work (SW) :

a. Assignments:

i Mention the areas of applications of a given comparator.

ii Compare the given comparators on the basis of working principle & mechanism, accuracy, specific use and advantages & limitations.

iii Calculate the limit gauge dimensions for a given set of data (at least 3 problems).

iv Given the tolerance of work piece, calculate the dimensions for maximum metal and minimum metal conditions.

b. Mini Project:

i Determine the specifications of plug and ring and snap gauges from IS standards.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESE of Classroom Instruction) :

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Introduction	2	2	6	10
II	Linear Measurements	2	2	8	12
III	Angular Measurements	2	2	8	12
IV	Measurement of Geometric Tolerances and Surface Roughness	2	2	8	12
V	Screw Thread Measurements and Gear Measurements	2	3	7	12
VI	Comparators & Limit Gauges	2	3	7	12
Total		**12**	**14**	**44**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Given the industrial situations, suggest the type of inspection applicable to each situation.	15	10	5
LE1.2	Given the situations, state where accuracy is necessary and where precision is necessary.	15	10	5
LE2.1	Measure the linear dimensions (length, diameter – outside & inside) of a given job using vernier caliper.	15	10	5
LE2.2	Measure the diameter – outside & inside) of a given job using micrometer.	15	10	5
LE 2.3	Measure the height of a given object using vernier height gauge.	15	10	5
LE2.4	To measure the depth of a given object using Depth gauge.	15	10	5
LE2.5	Check the parallelism and perpendicularity of a machine tool using dial gauge.	15	10	5
LE2.6	Set a job on lathe using dial gauge.	15	10	5

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE2.7	Set the adjustable snap gauge Go end and No-Go end for a give dimension using slip gauges combination.	15	10	5
LE3.1	Measure given angle of a component using Optical bevel protractor and Universal bevel protractor.	15	10	5
LE3.2	Set the Sine bar to a given known angle.	15	10	5
LE3.3	Measure the angle of taper of a given component using Sine bar.	15	10	5
LE3.4	Measure the angle of a given component with Angle Dekkar.	15	10	5
LE4.1	Check the straightness of a given job with straight edge method and Wedge method.	15	10	5
LE4.2	Check the straightness of a given job using precision level.	15	10	5
LE4.3	Check the straightness of a given job using autocollimator.	15	10	5
LE4.4	Check the flatness of a given job using precision level	15	10	5
LE4.5	Check the flatness of a given job using autocollimator.	15	10	5
LE4.6	Check the squareness of a given job using indicator method or Engineer's squareness tester.	15	10	5
LE4.7	Check the roundness of a given job using V block and dial indicator.	15	10	5
LE4.8	Using any one direct measuring instrument check the conformity or non-conformity of given three test specimen with values of roughness recommended by IS:3073.	15	10	5
LE5.1	Measure the effective diameter of a given screw thread using screw thread micrometer.	15	10	5
LE5.2	Measure the pitch of a given screw thread using screw pitch gauge.	15	10	5
LE5.3	Measure the major diameter, minor diameter, pitch and included angle using toolmaker's microscope.	15	10	5
LE5.4	Measure the gear tooth thickness using Gear tooth vernier caliper.	15	10	5
LE5.5	Check the gear tooth form using Toolmaker's microscope.	15	10	5
LE 6.1	Use dial indicator as mechanical comparator to inspect given components.	15	10	5
LE6.2	Select limit gauges for checking given dimensions.	15	10	5

*Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practicals ,

Legend: PRA: Process Assessment, PDA : Product Assessment

Note: Only one experiment has to be performed at the end semester examination of **30 Marks** as per assessment scheme

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Industrial visits
6. Industrial Training
7. Field Trips
8. Portfolio Based Learning
9. Role Play
10. Demonstration

11. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)
12. Brainstorming
13. Others

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition*
1	Engineering Metrology	R.K. Jain	Khanna Publishers	Latest edition 978-8174091536
2	Engineering Metrology	I.C. Gupta	Dhanpat Rai & Sons	Latest edition 978-8189928452
3	A Text Book of Engineering Metrology	M. Mahajan	Dhanpat Rai & Co.	Latest edition 1234567143086
4	Engineering metrology & measurements	N V Raghavendra and L krishnamurthy	Oxford	Latest edition ISBN-9780198085492
5	Principles of Engineering Metrology	Rega Rajendra	Jaico Publishing House	Latest edition 978-8179928370

*Latest edition of all above books should be referred

(b) Open source software and website address:

1. site.iugaza.edu.ps/aabuzarifa/files/METRO20152_CH1.pdf
2. nptel.ac.in/courses/112106179/19
3. https://www.scribd.com/doc/.../Engineering-Metrology-and-Measurements-Notes
4. uptusuccess.com/measurement-metrology-eme-403/
5. uptusuccess.com/measurement-metrology-eme-403/
6. https://www.youtube.com/watch?v=M7w4XQJa-TY
7. nptel.ac.in/courses/112106179/19
8. https://lecturenotes.in/notes/7488-mechanical-measurement-metrology-and-
9. reliability-.

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Manufacturers' Catalog
5. Lab Manuals

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	Vernier Calipers & Micrometers	Vernier Calipers :stainless steel body, Range : 0-150mm Resolution: 0.1mm Micrometer: Material- Carbon Steel Graduated to read up to 25mm in 0.01mm divisions with screw pitch of 0.5mm, ratchet lock nut	LE2.1 LE2.2
	Vernier height gauge.	Carbide tipped scriber. With fine adjustment. Made of stainless steel or carbon steel.	LE2.3
2	Depth gauge	Graduation: 0.05mm or 0.02mm, Stainless steel	LE2.4
3	Dial indicator with stand	Resolution: 0.001mm, Metric. Graduation. RANGE-1mm	LE2.5 LE2.6 LE4.6 LE4.7

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
			LE6.1
4	Slip gauges	Specification:112 pieces conforming to IS standards	LE2.7
5	Optical Bevel Protractor and Universal Bevel Protractor	Least count -1’	LE3.1
6	Sine Bar	Made from high quality alloy steel. Accuracy for Flatness, Squareness & parallelism is within 0.005mm. Centre distance between rollers is within +0.005mm. Hardness - 60 + Rc & Tempered Accuracy as per IS Standard	LE3.2 LE3.3
7	Angle Dekkar	Focal Length of Objective : 220mm Clear Aperture of Objective : 40mm Magnification : 11X Measuring Range : 60-0-60 minute in X-Y axis. Least Division on Reticle : 1 minute of arc Least Division with Micrometer Drum : 2 second of arc	LE3.4
8	Straightedge	Good quality, made of steel	LE4.1
9	Precision Level	Size: 200 x 20 x 25 mm (L x W x H), Bubble opening 50 x 8 mm Sensitivity 2 Min. 30 Sec per 2 mm arc division of the vial, Least count of graduation 2 mm	LE4.2 LE4.4
10	Autocollimator	Dual Axis. Read Out-Dual Axis Micrometer. Resolution. 1 Sec (5 microns/meter). Range of measurement. ± 20 Minutes. Max Working distance. 10 m. Clear Aperture. Centre Height. 35 mm.	LE4.3 LE4.5
11	Engineer’s Squareness tester		LE4.6
12	V-block	Magnetic, made of steel, maximum dia of work piece 50 mm	LE4.7
13	Stylus probe	Measurement Range 400µm Stylus tip Radius 5µm/2µm Stylus tip Material Diamond	LE4.8
14	Screw thread micrometer	Micrometer Type: Screw Thread Micrometer, 14-18 TPI Range (in): 0 - 1" Capacity Pitch Diameter Graduations (in): .001" Anvil/Spindle Material: Steel Anvil Type: Double V-anvil Spindle Type: Pointed spindle	LE5.1
15	Screw pitch gauge	For metric, whitworth and unified threads	LE5.2
16	Toolmaker’s microscope	Monocular optical tube, erect image, angle reading: min 6’, Range 360 degree, Eyepiece magnification 15x, Objective magnification 2x, Light source Tungstan bulb	LE5.3 LE5.5
17	Gear tooth Vernier Caliper	Sizes: 1-26 mm, Graduation 0.02mm	LE5.4
18	Limit Gauges	Adjustable snap guage range 0 to 300mm Fix type snap guage in single ended & double ended design, ring gauges in the range 4mm to 300mm	LE6.2
19	Vernier Calipers & Micrometers	Vernier calipers :stainless steel body, Range : 0-150mm Resolution: 0.1mm Micrometer: Material- Carbon Steel Graduated to read up to 25mm in 0.01mm divisions with	LE2.1 LE2.2

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
		screw pitch of 0.5mm, ratchet lock nut	

N) Mapping of POs and PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2	PSO-3
CO-1 Select the suitable inspection process for engineering situations/applications and correlate the cost of manufacturing with accuracy.	2	3	1	1	2	1	2	2	2	2	-	2	-
CO-2 Use appropriate instrument(s) for linear measurements.	2	3	3	3	2	2	2	2	2	2	-	2	-
CO-3 Use relevant instruments for angular measurements.	2	3	3	3	2	2	2	2	2	2	-	2	-
CO-4 Use relevant geometric tolerance and surface roughness instruments for dimensional applications.	2	3	3	3	2	2	2	2	2	2	-	2	-
CO-5 Use relevant instruments for screw thread measurements and gear measurements applications.	2	3	3	3	2	2	2	2	2	2	-	2	-
CO-6 Use relevant comparators and limit gauges for various situations/applications.	2	3	3	3	2	2	2	2	2	2	-	2	-

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2	**CO-1** Select the suitable inspection process for engineering situations/applications and correlate the cost of manufacturing with accuracy.	SO1.1- SO1.4	LE1.1 LE1.2	Unit-1.0 Introduction 1.1, 1.2, 1.3, 1.4	As mentioned in relevant page numbers.
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2	**CO-2** Use appropriate instrument(s) for linear measurements.	SO2.1 - SO2.5	LE2.1-LE2.7	Unit-2.0 Linear Measurements 2.1, 2.2 ,2.3 ,2.4, 2.5	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2	**CO-3** Use relevant instruments for angular measurements.	SO3.1 - SO3.6	LE3.1- LE3.4	Unit-3.0 Angular Measurements 3.1, 3.2, 3.3 3.4, 3.5, 3.6	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2	**CO-4** Use relevant geometric tolerance and surface roughness instruments for dimensional applications.	SO4.1 - SO4.3	LE4.1 - LE4.8	Unit-4.0 Measurement of Geometric Tolerances and Surface Roughness 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2	**CO-5** Use relevant instruments for screw thread measurements and gear measurements applications.	SO5.1 - SO5.3	LE5.1 - LE5.5	Unit-5.0 Screw Thread Measurements and Gear Measurements 5.1, 5.2 ,5.3, 5.4, 5.5	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2	**CO-6** Use relevant comparators and limit gauges for various situations/applications.	SO6.1 SO6.2	LE6.1 LE6.2	Unit-6.0 Comparators and Limit Gauges 6.1, 6.2, 6.3, 6.4	

Name of program:		**Diploma in Engineering**	**Semester: IV**
Branch	**:**	**Mechanical Engineering**	**Code: NIL**
Subject	**:**	**Indian Constitution**	**Total Tutorial Periods: NIL**
No. Of Periods	**:**	**2 Periods/Week**	

Course Content-

Unit 1 – The Constitution - Introduction
- The History of the Making of the Indian Constitution
- Preamble and the Basic Structure, and its interpretation
- Fundamental Rights and Duties and their interpretation
- State Policy Principles

Unit 2 – Union Government
- Structure of the Indian Union
- President – Role and Power
- Prime Minister and Council of Ministers
- Lok Sabha and Rajya Sabha

Unit 3 – State Government
- Governor – Role and Power
- Chief Minister and Council of Ministers
- State Secretariat

Unit 4 – Local Administration
- District Administration
- Municipal Corporation
- Zila Panchayat

Unit 5 – Election Commission
- Role and Functioning
- Chief Election Commissioner
- State Election Commission

Suggested Learning Resources:

S. No.	Title of Book	Author	Publication
1	Ethics and Politics of the Indian Constitution	Rajeev Bhargava	Oxford University Press, New Delhi, 2008
2	The Constitution of India	B.L. Fadia	Sahitya Bhawan; New edition (2017)
3	Introduction to the Constitution of India	DD Basu	Lexis Nexis; Twenty-Third 2018 edition

Suggested Software/Learning Websites:

a. https://www.constitution.org/cons/india/const.html
b. http://www.legislative.gov.in/constitution-of-india
c. https://www.sci.gov.in/constitution
d. https://www.toppr.com/guides/civics/the-indian-constitution/the-constitution-of-india/

Name of program: Diploma in Engineering **Semester: IV**
Branch : Mechanical Engineering **Code: NIL**
Subject : Physical and Mental fitness **Total Tutorial Periods: NIL**
No. Of Periods : 2 Periods/Week

Institution need to accord special & significant priority to physical & mental fitness of students and faculty in the campus and nominate a Nodal Officer for Fitness Implementation & Monitoring, whose activities would be monitored by and Institutional Committee. The following indicative guidelines/steps may be taken in this regard:

1. Physical fitness period or session may be incorporated into the academic calendar of the an institution, covering the aspects of sports, yoga, meditation, right diet etc. The physical fitness sessions may be staggered throughout the day to enable all students to participate.
2. Fitness Leaders in each institution to be created. For guiding students into physical fitness, services of students volunteer from the institution, ex-servicemen and other volunteers may be obtained on a daily & voluntary basis. 10 committed persons well versed in physical activity may be involved in the exercise.
3. Proper the utilization of existing infrastructure, encouraging students to climb stairs, walk at least 10,000 steps a day, use cycles within the campus by creating cycling zones etc.
4. (A) Every institution must organize intra institution game/sports competition/tournaments.
   (B) Sports meet : -
   Sports competition will be of four tier competition,
   (1) Intra institution sports meet
   (2) Inter institutional level sports meet at Regional level.
   (3) State level University sports meet.
   (4) National University sports meet.
5. The top leadership of the Institution and professors actively participate with staff and students in fitness activities on a periodic basis to lead by example, eg: cycling, running, aerobics, marathon, meditation activities etc.
6. Incorporating provisions of healthcare and wellness initiatives in the objectives of the institution.
7. Annual health check-ups by volunteer health doctors or voluntary organizations to monitor student health fitness and also maintain a record.
8. Providing guidance regarding a balanced nutritional diet, distribution of pamphlets and information material on the subject.
9. Redressing the emotional concerns of students in mental health. Awareness camps or sensitization workshops on depression, anxiety and stress management may be organized for faculty and students.
10. Inviting health icons and motivational speakers on health & fitness to address students in campus and regular conduct of outdoor sports events in campus.
11. Data pertaining to health & fitness activities of and institution should be placed on the website. Exemplary performers shall be selected subsequently for National level awards.