Ref No:

SRI KRISHNA INSTITUTE OF TECHNOLOGY

COURSE PLAN

Academic Year 2019-20

Program:	B E – Mechanical Engineering
Semester :	7
Course Code:	15ME742
Course Title:	Tribology
Credit / L-T-P:	3/ 3-0-0
Total Contact Hours:	40
Course Plan Author:	SAGAR HN

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Table of Contents

A. COURSE INFORMATION 4
1. Course Overview 4
2. Course Content 4
3. Course Material 5
4. Course Prerequisites 6
5. Content for Placement, Profession, HE and GATE 6
B. OBE PARAMETERS 7
1. Course Outcomes 7
2. Course Applications 7
3. Mapping And Justification 8
4. Articulation Matrix 8
5. Curricular Gap and Content 9
6. Content Beyond Syllabus 9
C. COURSE ASSESSMENT 10
1. Course Coverage 10
2. Continuous Internal Assessment (CIA) 10
D1. TEACHING PLAN - 1 11
Module - 1 11
Module – 2 12
E1. CIA EXAM – 1 13
a. Model Question Paper - 1 13
b. Assignment -1 13
D2. TEACHING PLAN - 2 18
Module – 3 18
Module – 4 19
E2. CIA EXAM – 2 20
a. Model Question Paper - 2 20
b. Assignment – 2 20
D3. TEACHING PLAN - 3 24
Module – 5 24
E3. CIA EXAM – 3 25
a. Model Question Paper - 3 25
b. Assignment – 3 26
F. EXAM PREPARATION 29
1. University Model Question Paper 29
2. SEE Important Questions 31
G. Content to Course Outcomes 32
1. TLPA Parameters 32
2. Concepts and Outcomes: 33

Note : Remove “Table of Content” before including in CP Book
Each Course Plan shall be printed and made into a book with cover page
Blooms Level in all sections match with A.2, only if you plan to teach / learn at higher levels

A. COURSE INFORMATION

1. Course Overview

Degree:	BE	Program:	ME
Semester:	7/VII	Academic Year:	2019-20
Course Title:	Tribology	Course Code:	15ME742
Credit / L-T-P:	03/3-0-0	SEE Duration:	180 minutes
Total Contact Hours:	42	SEE Marks:	80Marks
CIA Marks:	20	Assignment	1 / Module
Course Plan Author:	Sagar HN	Sign	Dt:
Checked By:		Sign	Dt:
CO Targets	CIA Target : ……. %	SEE Target:	……. %

Note: Define CIA and SEE % targets based on previous performance.

2. Course Content

Content / Syllabus of the course as prescribed by University or designed by institute. Identify 2 concepts per module as in G.

Module	Content	Teaching Hours	Identified Module Concepts	Blooms Learning Levels
1	**Introduction to Tribology:** Historical background, practical importance, and subsequent use in the field. **Lubricants:** Types and specific field of applications. Properties of lubricants, viscosity, its measurement, effect of temperature and pressure on viscosity, lubrication types, standard grades of lubricants, and selection of lubricants.	8 (4,4)	-Tribological properties -Tribological parameters	L2 understand L2 understand
2	**Friction:** Origin, friction theories, measurement methods, friction of metals and non-metals. **Wear:** Classification and mechanisms of wear, delamination theory, debris analysis, testing methods and standards. Related case studies.	8(4,4)	-Friction, -Contact mechanism	L2 understand L2 understand
3	**Hydrodynamic journal bearings:** Friction forces and power loss in a lightly loaded journal bearing,Petroff's equation, mechanism of pressure development in an oil film, and Reynold's equation in 2D. Introduction to idealized journal bearing, load carrying capacity, condition for equilibrium,Sommerfeld's number and it's significance; partial bearings, end leakages in journal bearing, numerical examples on full journal bearings only.	10 (5,.5)	-Lightly loaded journal bearing analysis -Full journal bearing analysis	L4 analyze L4 analyze
4	**Plane slider bearings with fixed/pivoted shoe:** Pressure distribution, Load carrying capacity, coefficient of friction, frictional resistance in a fixed/pivoted shoe bearing, center of pressure, numerical examples. Hydrostatic Lubrication: Introduction to hydrostatic lubrication, hydrostatic step bearings, load carrying capacity and oil flow through the hydrostatic step bearing, numerical examples.	8 (4,4)	-Plane slider bearings analysis -Hydrostatic step bearings analysis	L3 apply L3 apply
5	**Bearing Materials:** Commonly used bearings materials, and properties of typical bearing materials. Advantages and disadvantages of bearing materials. Introduction to Surface engineering: Concept and scope of surface engineering. **Surface modification** – transformation hardening, surface melting, thermo chemical processes. Surface Coating – plating, fusion processes, vapor phase processes. Selection of coating for wear and corrosion resistance.	8(4,4)	-Bearing Materials properties -surface engineering	L2 understand L2 understand
-	**Total**	**42**	-	-

3. Course Material

Books & other material as recommended by university (A, B) and additional resources used by course teacher (C).
1. Understanding: Concept simulation / video ; one per concept ; to understand the concepts ; 15 – 30 minutes

2. Design: Simulation and design tools used – software tools used ; Free / open source
3. Research: Recent developments on the concepts – publications in journals; conferences etc.

Modules	Details	Chapters in book	Availability
A	**Text books (Title, Authors, Edition, Publisher, Year.)**	-	-
1, 2, 3	"Introduction to Tribology", B. Bhushan, John Wiley & Sons, Inc., New York, 2002	3, 4	In Lib / In Dept
4, 5	"Engineering Tribology", J. A. Williams, Oxford Univ. Press, 2005.	2, 4	In Lib/ In dept
B	**Reference books (Title, Authors, Edition, Publisher, Year.)**	-	-
1, 2	"Engineering Tribology", Prasanta Sahoo, PHI Learning Private Ltd, New Delhi, 2011.		In Lib
1, 2	"Introduction to Tribology in bearings", B. C. Majumdar, Wheeler Publishing.	1,2	Not Available
3, 4, 5	"Tribology, Friction and Wear of Engineering Material", I. M.Hutchings, Edward Arnold, London, 1992.	4,2	In lib
C	**Concept Videos or Simulation for Understanding**	-	-
C1	Working of viscometer https://www.youtube.com/watch?v=Fvud81pYGOg – 15 Mins https://www.youtube.com/watch?v=TsBTI3tO5-8 – 5 Mins		
C2	Working Principle of fully Journal Bearing https://www.youtube.com/watch?v=Fvud92pYGOg – 10 Mins https://www.youtube.com/watch?v=TsBTI4tO– 5 Mins		
C3	Working Principle of fully Journal Bearing https://www.youtube.com/watch?v=Fvud81pYGOg – 5 Mins https://www.youtube.com/watch?v=TsBTI45tO5– 5 Mins		
C4	Bearing Materials properties https://www.youtube.com/watch?v=TsBTI78tO5-8 – 5 Mins		
	Lab : https://www.youtube.com/watch?v=P9e7hUNPGVs -		
D	**Software Tools for Design**	-	-
E	**Recent Developments for Research**	-	-
	Improve the bearing material properties https://ieeexplore.ieee.org/abstract/document/6891996		
F	**Others (Web, Video, Simulation, Notes etc.)**	-	-
1	How viscometer works ? https://www.youtube.com/watch?v=nA_tgIygvNo		
?			

4. Course Prerequisites

Refer to GL01. If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

Students must have learnt the following Courses / Topics with described Content . . .

Modules	Course Code	Course Name	Topic / Description	Sem	Remarks	Blooms Level
1	15ME54	Design of machine element -II	Bearing design	6		Understand L2
2	15ME32	Material Science	Wear and Friction	3	-	Understand L2
-						

-						

5. Content for Placement, Profession, HE and GATE

The content is not included in this course, but required to meet industry & profession requirements and help students for Placement, GATE, Higher Education, Entrepreneurship, etc. Identifying Area / Content requires experts consultation in the area.

Topics included are like, a. Advanced Topics, b. Recent Developments, c. Certificate Courses, d. Course Projects, e. New Software Tools, f. GATE Topics, g. NPTEL Videos, h. Swayam videos etc.

Modules	Topic / Description	Area	Remarks	Blooms Level
1	Wear ,friction , Bearing Material	Higher Study	Gap A seminar on Bearing Material	Understand L2
-				
-				

B. OBE PARAMETERS

1. Course Outcomes

Expected learning outcomes of the course, which will be mapped to POs. Identify a max of 2 Concepts per Module. Write 1 CO per Concept.

Modules	Course Code.#	Course Outcome **At the end of the course, student should be able to . . .**	Teach. Hours	Concept	Instr Method	Assessment Method	Blooms' Level
1	15ME742.1	Understand the fundamentals of tribology	4	Tribological properties	Lecture	Slip Test	L2 understand
1	15ME742.2	Understand the parameters associated with tribology	4	Tribological parameters	Lecture/ Tutorial	Assignment	L2 understand
2	15ME742.3	Understand the concepts of tribological components experiencing the relative motion	4	friction	Lecture	Assignment	L2 understand
2	15ME742.4	Understand the concepts of contact mechanism involved in relative motion	4	Contact mechanism	Lecture	Slip Test	L2 understand
3	15ME742.5	Analyze requirements for design a lightly load journal bearings	5	Lightly loaded journal bearing analysis	Lecture	Slip test	L4 Analyse
3	15ME742.6	Analyze terminology of full journal bearing	5	Full journal bearing analysis	Lecture/Tutorial	Assignment	L4 Analyse
4	15ME742.7	Apply the performance characteristics of bearing in design of plane slider bearing	4	Plane slider bearings analysis	Lecture/Tutorial	Assignment	L3 apply
4	15ME742.8	Apply concepts of hydro static lubrication for design a step bearing	4	hydrostatic step bearings analysis	Lecture/Tutorial	Assignment	L3 apply
5	15ME742.9	Understand bearing material properties and selection procedure	4	Bearing Materials properties	Lecture	Assignment	L2 understand
5	15ME742.10	Understand principles of surface engineering for different applications of tribology	4	surface engineering	Lecture	Assignment	L2 understand
-	**-**	**Total**	**42**	**-**	**-**	**-**	**L2-L4**

2. Course Applications

Write 1 or 2 applications per CO.

Students should be able to employ / apply the course learnings to . . .

Modules	Application Area Compiled from Module Applications.	CO	Level

1	Application tribology in the transport industry focused on reliability, ensuring the safe, continuous operation of machine components,tribology research concentrated on the design and effective lubrication of machine components	CO1	L2
1	The use of lubricants which minimize direct surface contact reduces tool wear and power requirements	CO2	L2
2	In drum brakes,brake shoes or pads are pressed outwards against a rotating cylinder (brake drum) to create friction. Since braking discs can be more efficiently cooled than drums, disc brakes have better stopping performance.	CO3	L2
2	Wear in machine element, together with other processes such as fatigue and , creep causes functional surfaces to degrade, eventually leading to material failure or loss of functionality.	CO4	L2
3	Journal bearings support the cylindrical rotating shaft. Journal bearing are designed based on lubricant and lubrication mechanisms	CO5	L4
3	application can be found in a car's crankshaft and camshaft. In my industry we use tilt pad bearings in turbo machinery (e.g. compressors, turbines).	CO6	L4
4	plain bearing it is simply a shaft rotating in a bearing. In locomotive and rail road car applications a journal bearing specifically referred to the plain bearing once used at the ends of the axles of railroad wheel sets	CO7	L3
4	Hydrostatic bearing in high precision machine tools ,pad for automotive application,high-precision applications in measuring, testing and machine tool engineering	CO8	L3
5	Stainless steel materials are used to make bearing components because it is more resistant to surface corrosion due to the higher content of chromium (~18%) with the addition of nickel. The material needs to be protected from corrosion with a coating of oil/grease (cages) or by plating (shields).	CO9	L2
5	Surface engineering techniques are being used in the automotive, aerospace, missile, power, electronic, biomedical, textile, petroleum, petrochemical, chemical, steel, cement, machine tools. Surface engineering techniques can be used to develop a wide range of functional properties, including physical, chemical, electrical, electronic, magnetic, mechanical, wear-resistant and corrosion-resistant properties at the required substrate surfaces. Almost all types of materials, including metals, ceramics, polymers, and composites can be coated on similar or dissimilar materials.	CO10	L2

3. Mapping And Justification

CO – PO Mapping with mapping Level along with justification for each CO-PO pair.
To attain competency required (as defined in POs) in a specified area and the knowledge & ability required to accomplish it.

Modules	Mapping		Mapping Level	Justification for each CO-PO pair	Level
-	**CO**	**PO**	-	**'Area': 'Competency' and 'Knowledge' for specified 'Accomplishment'**	-
1	CO1	PO1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of fundamentals of tribology is essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	L2
1	CO1	PO2	2	'Problem Analysis': Analyzing problems require knowledge / understanding of Characteristics of tribology to accomplish solutions to complex engineering problems in Mechanical Engineering.	L3
1	CO2	po1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of parameters associated with tribologyis essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	
1	CO2	p02	2	'Problem Analysis': Analyzing problems require knowledge / understanding of Operation of viscometer to accomplish solutions to complex engineering problems in Mechanical Engineering.	
2	CO3	PO1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of concepts of contact mechanism involved in relative motion is essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	
2	CO3	PO2	2	'Problem Analysis': Analyzing problems require knowledge / understanding of mechanism of Wear to accomplish solutions to complex engineering problems in Mechanical Engineering.	
2	CO4	PO1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of fundamentals	

				of tribology is essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	
2	CO4	PO2	2	'Problem Analysis': Analyzing problems require knowledge / understanding of parameters associated with tribology to accomplish solutions to complex engineering problems in Mechanical Engineering.	
3	CO5	PO1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of lightly load journal bearings is essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	
3	CO5	PO2	2	'Problem Analysis': Analyzing problems require knowledge / understanding of terminology of full journal bearing to accomplish solutions to complex engineering problems in Mechanical Engineering.	
3	CO6	PO1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of full journal bearing is essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	
3	CO6	PO2	2	'Problem Analysis': Analyzing problems require knowledge / understanding of design parameters associated with lightly loaded journal bearing to accomplish solutions to complex engineering problems in Mechanical Engineering.	
4	CO7	PO1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of plane slider bearing is essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	
4	CO7	PO2	2	'Problem Analysis': Analyzing problems require knowledge / understanding of performance characteristics of bearing to accomplish solutions to complex engineering problems in Mechanical Engineering.	
4	co8	PO1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of hydro static lubrication is essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	
4	co8	PO2	2	'Problem Analysis': Analyzing problems require knowledge / understanding of performance characteristics of step bearing to accomplish solutions to complex engineering problems in Mechanical Engineering.	
5	co9	PO1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of Bearing Materials is essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	
5	co9	PO2	2	'Problem Analysis': Analyzing problems require knowledge / understanding of Bearing Materials properties to accomplish solutions to complex engineering problems in Mechanical Engineering.	
5	co10	PO1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of surface engineering is essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	
5	co10	PO2	2	'Problem Analysis': Analyzing problems require knowledge / understanding of surface engineering and its applications to accomplish solutions to complex engineering problems in Mechanical Engineering.	

4. Articulation Matrix

CO – PO Mapping with mapping level for each CO-PO pair, with course average attainment.

-	-	Course Outcomes	Program Outcomes														-
Modules	CO.#	**At the end of the course student should be able to . . .**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	Level
1	15ME742.1	Understand the fundamentals of tribology	√	√														L2
1	15ME742.2	Understand the parameters associated with tribology	√	√														L2
2	15ME742.3	Understand the concepts of tribological components experiencing	√	√														L2

		the relative motion																
2	15ME742.4	Understand the concepts of contact mechanism involved in relative motion	√	√														L2
3	15ME742.5	Analyze requirements for design a lightly load journal bearings	√	√														L4
3	15ME742.6	Analyze terminology of full journal bearing	√	√														L4
4	15ME742.7	Apply the performance characteristics of bearing in design of plane slider bearing	√	√														L3
4	15ME742.8	Apply concepts of hydro static lubrication for design a step bearing	√	√														L3
5	15ME742.9	Understand bearing material properties and selection procedure	√	√														L2
5	15ME742.10	Understand principles of surface engineering for different applications of tribology	√	√														L2
-	**CS501PC**	**Average attainment (1, 2, or 3)**	√	√														-
-	*PO, PSO*	*1.Engineering Knowledge; 2.Problem Analysis; 3.Design / Development of Solutions; 4.Conduct Investigations of Complex Problems; 5.Modern Tool Usage; 6.The Engineer and Society; 7.Environment and Sustainability; 8.Ethics; 9.Individual and Teamwork; 10.Communication; 11.Project Management and Finance; 12.Life-long Learning; S1.Software Engineering; S2.Data Base Management; S3.Web Design*																

5. Curricular Gap and Content

Topics & contents not covered (from A.4), but essential for the course to address POs and PSOs.

Modules	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1	Electron Tubes & Amplifiers	Seminar	2nd week / date	Dr XYZ, Inst	List from B4 above
2					
3					
4					
5					

6. Content Beyond Syllabus

Topics & contents required (from A.5) not addressed, but help students for Placement, GATE, Higher Education, Entrepreneurship, etc.

Modules	Gap Topic	Area	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1	ANSYS HFSS - High Frequency Software Simulation Tool	Placement, GATE, Higher Study, Entrepreneurship.	Presentation by students & Mini Project	3rd week / date	Dr ABC, Inst. Self	List from B4 above
1						
2						
2						
3						
3						
4						
4						
5						
5						

C. COURSE ASSESSMENT

1. Course Coverage

Assessment of learning outcomes for Internal and end semester evaluation. Distinct assignment for each student. 1 Assignment per chapter per student. 1 seminar per test per student.

Modules	Title	Teach. Hours	No. of question in Exam						CO	Levels
			CIA-1	CIA-2	CIA-3	Asg	Extra Asg	SEE		
1	Introduction to tribology	8	2	-	-	1	1	2	CO1, CO2	L2, L2
2	Friction and wear	8	-	2	-	1	1	2	CO3, CO4	L2, L2
3	Hydrodynamic journal bearings	10	2	-	-	1	1	2	CO5, CO6	L3, L3
4	Plane slider bearings with fixed/pivoted shoe and hydrostatic bearings	8	-	2	-	1	1	2	CO7, C08	L3, L3
5	Bearing Materials and Introduction to Surface engineering	8	-	-	4	4	1	2	CO9, CO10	L2, L2
-	**Total**	**42**	**4**	**4**	**4**	**5**	**5**	**10**	-	-

2. Continuous Internal Assessment (CIA)

Assessment of learning outcomes for Internal exams. Blooms Level in last column shall match with A.2.

Modules	Evaluation	Weightage in Marks	CO	Levels
1, 2	CIA Exam – 1	15	CO1, CO2, CO5, CO6	L2,L2,L3, L3
3, 4	CIA Exam – 2	15	CO3, CO4, CO7, C08	L2, L2,L3,L3
5	CIA Exam – 3	15	CO9, CO10	L2,L2
1, 2	Assignment - 1	05	CO1, CO2, CO5, CO6	L2,L2,L3, L3
3, 4	Assignment - 2	05	CO3, CO4, CO7, CO8	L2, L2,L3,L3
5	Assignment - 3	05	CO9, CO10	L2,L2
1, 2	Seminar - 1	00	CO1, CO2, CO5, CO6	L2,L2,L3, L3
3, 4	Seminar - 2	00	CO3, CO4, CO7, CO8	L2, L2,L3,L3
5	Seminar - 3	00	CO9, CO10	L2,L2
1, 2	Quiz - 1	-	-	-
3, 4	Quiz - 2	-	-	-
5	Quiz - 3	-	-	-
		-	-	
1 - 5	Other Activities – Mini Project	-	-	-
	Final CIA Marks	**20**	-	-

D1. TEACHING PLAN - 1

Module - 1

Title:	**Introduction to Tribology**	Appr Time:	12 Hrs

a	*Course Outcomes*	CO	Blooms
-	At the end of the topic the student should be able to . . .	-	**Level**
1	understand the fundamentals of tribology	CO1	L2
2	understand the parameters associated with tribology	CO2	L2
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	-	-
1	Introduction to tribology:Historical background	C01	L2
2	Practical importance and subsequent use in the field		
3	Lubricants: Types and specific field of applications.	CO2	L2
4	Properties of lubricants, viscosity, its measurement,	CO2	L2
5	effect of temperature and pressure on viscosity, lubrication types,	CO2	L2
6	Standard grades of lubricants, and selection of lubricants.	CO2	L2
c	**Application Areas**	-	-
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	Application tribology in the transport industry focused on reliability, ensuring the safe, continuous operation of machine components,tribology research concentrated on the design and effective lubrication of machine components	CO1	L2
2	The use of lubricants which minimize direct surface contact reduces tool wear and power requirements	CO2	L2
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
1	Explain historical background of tribology	CO2	L2
2	Explain practical importance of tribology	CO2	L2
3	Explain application of tribology in various fields	CO2	L2
4	Define lubrication	CO2	L2
5	Explain types and application of lubricants	CO2	L2
6	Explain the properties of lubricants	CO2	L2
7	Define viscosity. state the law of viscosity	CO2	L2
8	Explain the method of measurement of viscosity	CO2	L2
9	Explain standard grades of lubricant	CO2	L2
10	Distinguish between: i) Dynamic and kinematic viscosity ii) Fluidity and viscosity iii)Newtonian and non-Newtonian fluid iv) Mineral oil and vegetable oil (for lubrication) v) Full and partial journals bearing.	CO2	L2
11	Sketch and explain working of any two viscosity measuring apparatus types.	CO2	L2
12	Distinguish between: i) Dynamic and kinematic viscosity ii) Fluidity and viscosity in) Newtonian and non-Newtonian fluid iv) Mineral oil and vegetable oil (for lubrication) v) Full and partial journal bearing.	CO2	L2
13	Sketch and explain working of any two viscosity measuring apparatus types. Add a note on the effect of temperature and pressure on viscosity of a fluid.	CO2	L2
	Explain historical background of tribology	CO2	L2
e	**Experiences**	-	-
1		CO1	L2
2			
3			
4		CO2	L3
5			

Module – 3

Title:	Hydrodynamic journal bearings	Appr Time:	7 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Analyze requirements for design a lightly load journal bearings	CO5	L3
2	Analyze terminology of full journal bearing	CO6	L3
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	-	-
7	Hydrodynamic journal bearings: Friction forces and power loss in a lightly loaded journal bearing,	CO5	L3
8	Petroff's equation, mechanism of pressure development in an oil film	CO5	L3
9	Reynold's equation in 2D.	CO5	L3
10	Introduction to idealized journal bearing	CO5	L3
11	load carrying capacity, condition for equilibrium.	CO6	L3
12	Sommerfeld's number and it's significance;	CO6	L3
13	partial bearings.	CO6	L3
14	end leakages in journal bearing,	CO6	L3
15	numerical examples on full journal bearings only.	CO5	L3
		CO6	L3
c	**Application Areas**	-	-
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	Journal bearings support the cylindrical rotating shaft. Journal bearing are designed based on lubricant and lubrication mechanisms	CO5	L3
2	application can be found in a car's crankshaft and camshaft. In my industry we use tilt pad bearings in turbo machinery (e.g. compressors, turbines).	CO6	L3
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
1	Define hydrodynamic journals bearings	CO5	L3
2	Explain types of hydrodynamic journals bearings	CO5	L3
3	Derive expression for frictional force and power loss in lightly loaded journals bearings	CO5	L3
4	Define friction force	CO5	L3
5	Explain and derive petroff's equation	CO5	L3
6	Explain the mechanism of pressure development in oil film	CO5	L3
7	Derive an expression for Reynold's equation in 2-d	CO5	L3
8	Derive expression for load carring capacity of idealized journal bearings	CO5	L3
9	Explain Sommerfeld's number and it;s significance	CO5	L3
10	Explain end leakages in journals bearings	CO5	L3
11	A full journals bearings have a specification, shaft diameter 4.5cms,bearing length 6.5cms, radial clearance ratio is 0.0015, speed 2800rpm, radial load 800N, viscosity of lubricant at effective, temperature of oil 1.2*10¯6Reyn, consider bearings as a lightly loaded , determine i)frictional torque at the shaft ii)co-efficient of friction iii)power loss	CO6	L3
12	What are the advantages and disadvantages of hydrodynamic journal bearings	CO6	L3
13	Design a journal bearing with the following specifications: Journal diameter=100mm Journal speed=3000rpm Radial load=15kN.	CO6	L3
14	Design a journal bearing with the following specifications Joumal diameter = 200	CO6	L3

	Diametrical clearance ratio temperature operatin pm load on piston = 80 KN, Engine speed = 200 rpm, 9 Determine heat generated and heat disipiated, given bient temperature = 25°C, Attitude = 0.8, Absolute , assume as square bearing. (1) Power loss (i) Coefficient of friction.		
15	Design a journal bearing with the following specifications, Diameter of pocket = 100 mm, Vertical thrust of bearing = 000 rpm, Viscosity = 0.025 pa.sec, film thickness = 0.125 mm. oil flow, (1) Power loss (i) Coefficient of friction.	CO6	L3
16	A slider bearing with a rectangular pivoted shoe has the following specifications. length of shoe in the direction of motion = 75 mm,width of shoe = 112 mm,velocity of moving member = 200 mails, viscosity of fluid = 32ep, permissible minimum oil film thickness = 0.0255 min. Assume inclination of bearing corresponding to q =1.2. Determine ; 1) Load carrying capacity and Power loss in bearing 2)Coefficient of friction Take into consideration the influence of end leakage on the performance of the bearing.	CO6	L3
17	State Petroft's law and explain its significance	CO6	L3
18	With the help of neat sketches explain the working of i) Ostwakt viscometer ii) Saybolt Viscometer.	CO6	L3
19	What is lightly loaded bearing? Derive petroffs equation for frictional force and co-efficient of friction in lightly loaded bearing.	CO6	L3
20	A lightly loaded bearing has the following specifications: Journal diameter = 25mm, bearing length = 57mm, Radial clearance = 5x10- 2 mm, Journal speed = 25,000rpm, Radial Load = 910N, Viscosity of the lubricant = 24cp. Calculate: i) Coefficient of friction ii) Frictional Torque and iii) Power loss due to viscous friction	CO6	L3
21	Determine i) Load carrying capacity ii) Frictional force iii) Coefficient of friction and iv) Power loss due to friction for an idealized full Journal bearing having the following specifications : Diameter of the Journal = 50mm, length of bearing = 65mm, Speed of the Journal =1200rpm, Radial clearance = 0.025mm, Average viscosity = 0.01125PaS, Attitude = 0.8	CO6	L3
22	A partial self contained 120°, centrally loaded bearing has the following specifications : Journal diameter = 100mm, Bearing length = 125mm, Journal speed = 400rpm, Radial clearance = 0.0625mm, Minimum film thickness = 6.25x10-3mm, Viscosity of lubricating oil = 0.018Pa.S. Determine i) Load carrying capacity of the bearing ii) Power loss in the bearing iii) Maximum pressure in oil film.	CO6	L3
23	Explain with a neat sketch Tower's experiment	CO6	L3
24	The following specification refers to a full journal bearing, Journal diameter = 60 mm, Bearing length = 75 mm, Journal speed = 2000 rpm, Radial clearance = 0.04 mm, Viscosity of lubricant = 0.01 Pa Sec, Eccentricity ratio = 0.8, Inlet pressure = 0.3 MPa, Location of inlet hole = 300°. Determine maximum and minimum pressure and their location.	CO6	L3
25	Explain with a neat sketch mechanism of pressure development in an oil film.	CO6	L3
26	The following data refers to a slider bearing with pivoted shoe: Length of the bearing = 500 mm, Width of the bearing = 500 mm, Velocity of runner = 8 m/sec, Oil viscosity = 0.054 PaSec, Maximum and minimum film thickness = 0.15 mm and 0.075 mm. Determine (i) Load that may be carried by the bearing. (ii) Coefficient of friction (iii) Power loss.	CO6	L3
27	A lightly loaded journal bearing has the following specifications: Diameter of journal = 50 mm Bearing length = 80 mm Diametral clearance ratio = 0.002 Radial load — 750 N Viscosity — 10 cP Speed = 4000 rpm Determine: i) Frictional torque, ii) Coefficient of friction, iii) Power loss.	CO6	L3
28	A full journal bearing has the following specifications: Diameter of journal = 75 mm	CO6	L3

	Length of bearing = 60 mm Oil film temperature = 96°C Radial clearance = 0.05 mm Oil film thickness — 7.9 x10^3 mm Lubricating oil is SAE 20. Lubricant is delivered to the bearing under a pressure through a single inlet pressure hole in an unloaded bearing region. Determine inlet pressure required if the rate of oil flow through the bearing must be 312 mm3 /sec in order to control bearing temperature.		
29	A lightly loaded journal bearing has the following specification : Diameter of Journal = 50mm ; Bearing length = 80mm ; Diametral clearance ratio = 0.002 Radial load = 750N ; Viscosity of lubricant = 10Cp ; Speed = 4000rpm. Determine i) Frictional torque on journal ii) Co — efficient of friction Power loss.	CO6	L3
30	Derive the Reynold's equation two dimensions. Also state the assumptions.	CO6	L3
31	A lightly loaded journal bearing has the following specifications : Journal diameter = 100 mm; Bearing length = 80 mm; radial clearance = 0.05 mm; radial load = 1000 N; absolute viscosity of oil = 0.015 pas — sec. Using Petrofis equation, determine : i) Speed of journal which corresponds to a co-efficient of friction of 0.4. ii) Power loss at this speed.	CO6	L3
32	An idealized full journal bearing has the following data : Diameter of journal = 50 mm; bearing length = 65 mm; speed = 1200 rpm; radial clearance = 0.025 mm; average viscosity = 0.001125 pas-sec; attitude = 0.8. Calculate : i) Load carrying capacity ii) Co-efficient of friction iii) Power loss in bearing.	CO6	L3
33	A 120° centrally loaded bearing has the following specifications : Diameter of journal = 100 mm; length of bearing = 130 mm; diameter clearance = 0.15 mm; oil used SAE 60; minimum film thickness = 0.0045 mm; speed of journal = 600 rpm; bearing operating temperature = 95°C ; considering end leakage determine : i) Load carrying capacity ii) Power loss in the bearing iii) Expected maximum pressure in the bearing.	CO6	L3
34	A lightly loaded full journal bearing of an air compressor has the following specifications : Journal diameter = 64 mm, Bearing length = 57 mm, Radial clearance = 0.05 mm, Journal speed = 25000 rpm, Viscosity of the lubricating oil = 2.4 Cp, Radial load = 890 N. Determine : i) Torque, ii) Coefficient of friction, iii) Frictional force, iv) Power loss.	CO6	L3
35	The following data refers to a journal bearing : Journal diameter = 30 mm, Journal speed = 2000 rpm, Bearing length = 60 mm, Radial clearance = 0.02 mm,	CO6	L3

	Inlet pressure = 0.3 MPa, Hole location = 300°, Viscosity of oil = 20 cp, Attitude = 0.8. Plot the pressure distribution diagram. If the distribution is not satisfactory, what alternatives are required to make?		
e	**Experiences**	-	-
1		CO3	L2
2			
3			
4		CO4	L3
5			

E1. CIA EXAM – 1

a. Model Question Paper - 1

Crs Code:		15ME742	Sem:	VII	Marks:	30	Time:	75 minutes		
Course:		TRIBOLOGY								
-	**-**	**Note: Answer all questions, each carry equal marks. Module : 1, 2**						**Marks**	**CO**	**Level**
1	a	Explain practical importance of tribology?						5	CO1	L2
	b	Explain application of tribology in various fields						5	CO1	L2
	c	Define lubrication explain standard grade of lubricant						5		
		OR								
2	a	Explain the properties of lubricants and it's application of lubricants						5	CO2	L2
	b	Explain the method of measurement of viscosity						5	CO2	L2
	c	Define viscosity. state the law of viscosity						5	CO2	L2
3	a	Derive expression for frictional force and power loss in lightly loaded journals bearings						8	CO5	L3
	b	A full journals bearings have a specification, shaft diameter 4.5cms,bearing length 6.5cms, radial clearance ratio is 0.0015, speed 2800rpm, radial load 800N, viscosity of lubricant at effective, temperature of oil 1.2*10-6Reyn, consider bearings as a lightly loaded , determine i)frictional torque at the shaft ii)co-efficient of friction iii)power loss						7	CO5	L3
4	a	Explain sommerfeld's number and it;s significance						7	CO6	L3
	b	Derive expression for load carring capacity of idealized journal bearings						8	CO6	L3

b. Assignment -1

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions										
Crs Code:	15ME742	Sem:	VII	Marks:	5	Time:	90 – 120 minutes			
Course:	TRIBOLOGY				Module : 1, 2					
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.										
SNo	**USN**	**Assignment Description**						**Marks**	**CO**	**Level**
1	1KT16ME	Explain historical background of tribology						5	CO1	L2
2	1KT16ME	Explain practical importance of tribology						5	CO1	L2
3	1KT16ME	Explain application of tribology in various fields						5	CO1	L2
4	1KT16ME	Define lubrication						5	CO1	L2
5	1KT16ME	Explain types and application of lubricants						5	CO1	L2
6	1KT16ME	Explain the properties of lubricants						5	CO1	L2
7	1KT16ME	Define viscosity. state the law of viscosity						5	CO1	L2
8	1KT16ME	Explain the method of measurement of viscosity						5	CO1	L2
9	1KT16ME	Explain standard grades of lubricant						5	CO1	L2
10	1KT16ME	Define hydrodynamic journals bearings						5	CO1	L2

11	1KT16ME	Explain types of hydrodynamic journals bearings	5	CO1	L2
12	1KT16ME	Derive expression for frictional force and power loss in lightly loaded journals bearings	5	CO1	L2
13	1KT16ME	Define friction force	5	CO1	L2
14	1KT16ME	Explain and derive petroff's equation	5	CO1	L2
15	1KT16ME	Explain the mechanism of pressure development in oil film	5	CO1	L2
16	1KT16ME	Derive an expression for Reynold's equation in 2-d	5	CO1	L2
17	1KT16ME	Derive expression for load carring capacity of idealized journal bearings	5	CO1	L2
18	1KT16ME	A full journals bearings have a specification, shaft diameter 4.5cms,bearing length 6.5cms, radial clearance ratio is 0.0015, speed 2800rpm, radial load 800N, viscosity of lubricant at effective, temperature of oil 1.2*10-6Reyn, consider bearings as a lightly loaded , determine i)frictional torque at the shaft ii)co-efficient of friction iii)power loss			
19	1KT16ME	Explain sommerfeld's number and it;s significance	5	CO1	L2
20	1KT16ME	Explain end leakages in journals bearings	5	CO1	L2
21	1KT16ME	Explain historical background of tribology	5	CO1	L2
22	1KT16ME	Explain practical importance of tribology	5	CO1	L2
23	1KT16ME	Explain application of tribology in various fields	5	CO1	L2
24	1KT16ME	Define lubrication	5	CO1	L2
25	1KT16ME	Explain types and application of lubricants	5	CO1	L2
26	1KT16ME	Explain the properties of lubricants	5	CO1	L2
27	1KT16ME	Define viscosity. state the law of viscosity	5	CO1	L2
28	1KT16ME	Explain the method of measurement of viscosity	5	CO2	L2
29	1KT16ME	Explain standard grades of lubricant	5	CO2	L2
30	1KT16ME	Define hydrodynamic journals bearings	5	CO2	L2
31	1KT16ME	Explain types of hydrodynamic journals bearings	5	CO2	L2
32	1KT16ME	Derive expression for frictional force and power loss in lightly loaded journals bearings	5	CO2	L2
33	1KT16ME	Define friction force	5	CO2	L2
34	1KT16ME	Explain and derive petroff's equation	5	CO2	L2
35	1KT16ME	Explain the mechanism of pressure development in oil film	5	CO2	L2
36	1KT16ME	Derive an expression for Reynold's equation in 2-d	5	CO2	L2
37	1KT16ME	Derive expression for load carring capacity of idealized journal bearings	5	CO2	L2
38	1KT16ME	A full journals bearings have a specification, shaft diameter 4.5cms,bearing length 6.5cms, radial clearance ratio is 0.0015, speed 2800rpm, radial load 800N, viscosity of lubricant at effective, temperature of oil 1.2*10-6Reyn, consider bearings as a lightly loaded , determine i)frictional torque at the shaft ii)co-efficient of friction iii)power loss	5	CO2	L2
39	1KT16ME	Explain sommerfeld's number and it;s significance	5	CO2	L2
40	1KT16ME	Explain end leakages in journals bearings	5	CO2	L2
41	1KT16ME	Explain historical background of tribology	5	CO2	L2
42	1KT16ME	Explain practical importance of tribology	5	CO2	L2
43	1KT16ME	Explain application of tribology in various fields	5	CO2	L2
44	1KT16ME	Define lubrication	5	CO2	L2
45	1KT16ME	Explain types and application of lubricants	5	CO2	L2
46	1KT16ME	Explain the properties of lubricants	5	CO2	L2
47	1KT16ME	Define viscosity. state the law of viscosity	5	CO2	L2
48	1KT16ME	Explain the method of measurement of viscosity	5	CO2	L2
49	1KT16ME	Explain standard grades of lubricant	5	CO2	L2
50	1KT16ME	Define hydrodynamic journals bearings		CO5	L3
51	1KT16ME	Explain types of hydrodynamic journals bearings		CO5	L3
52	1KT16ME	Derive expression for frictional force and power loss in lightly loaded		CO5	L3

		journals bearings			
53	1KT16ME	Define friction force		CO5	L3
54	1KT16ME	A full journals bearings have a specification, shaft diameter 4.5cms,bearing length 6.5cms, radial clearance ratio is 0.0015, speed 2800rpm, radial load 800N, viscosity of lubricant at effective, temperature of oil 1.2*10-6Reyn, consider bearings as a lightly loaded , determine i)frictional torque at the shaft ii)co-efficient of friction iii)power loss		CO5	L3
55	1KT16ME	Explain and derive petroff's equation		CO5	L3
56	1KT16ME	Explain the mechanism of pressure development in oil film		CO5	L3
57	1KT16ME	Derive an expression for Reynold's equation in 2-d		CO5	L3
58	1KT16ME	Derive expression for load carring capacity of idealized journal bearings		CO5	L3
59	1KT16ME	Explain sommerfeld's number and it;s significance		CO5	L3
60	1KT16ME	Explain end leakages in journals bearings		CO5	L3

D2. TEACHING PLAN - 2

Module – 2

Title:	Friction and wear	Appr Time:	12 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Understand the concepts of tribological components experiencing the relative motion	CO5	L2
2	understand the concepts of contact mechanism involved in relative motion	CO6	L3
b	***Course Schedule***		
Class No	**Portion covered per hour**	-	-
16	Friction: Origin, friction theories	CO5	L3
17	friction of metals and non metals		
18	measurement methods.		
19	Wear: Classification and mechanisms of wear,	CO5	L3
20	De lamination theory, debris analysis.		
21	Testing methods and standards.	CO5	L3
22	Related case studies.		
c	**Application Areas**	-	-
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	In drum brakes,brake shoes or pads are pressed outwards against a rotating cylinder (brake drum) to create friction. Since braking discs can be more efficiently cooled than drums, disc brakes have better stopping performance.	CO3	L2
2	Wear in machine element, together with other processes such as fatigue and , creep causes functional surfaces to degrade, eventually leading to material failure or loss of functionality.	CO4	L2
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
18	Define friction	CO3	L2
19	State and explain friction theories	CO3	L2
20	Explain measurement method for friction	CO3	L2
21	Explain friction of metals and non metals	CO3	L2
22	Define wear explain classification	CO3	L2
23	Explain mechanism of wear	CO3	L2
24	Explain delamination theories	CO4	L2
25	Explain debris analysis	CO4	L2
26	Explain testing methods and related standard to measurement of wear	CO4	L2

27	Define friction	CO4	L2
28	State and explain friction theories	CO4	L2
29	Explain measurement method for friction	CO4	L2
e	**Experiences**	-	-
1		CO6	L2
2			
3			
4		CO6	L3
5			

Module – 4

Title:	Plane slider bearings with fixed/pivoted shoe and hydrostatic bearings	Appr Time:	13 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Apply the performance characteristics of bearing in design of plane slider bearing	CO3	L2
2	Apply concepts of hydro static lubrication for design a step bearing	CO4	L2
b	***Course Schedule***		
Class No	**Portion covered per hour**	-	-
23	Plane slider bearings with fixed/pivoted shoe:	C07	L3
24	Pressure distribution, Load carrying capacity.		
25	coefficient of friction, frictional resistance in a fixed/pivoted shoe bearing	C07	L3
26	center of pressure	C07	L3
27	numerical examples.		
28	Hydrostatic Lubrication: Introduction to hydrostatic lubrication	CO8	L3
29	hydrostatic step bearings,		
30	Load carrying capacity and oil flow through the hydrostatic step bearing,	CO8	L3
31	Numerical examples.	CO8	
c	**Application Areas**	-	-
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	plain bearing it is simply a shaft rotating in a bearing. In locomotive and rail road car applications a journal bearing specifically referred to the plain bearing once used at the ends of the axles of railroad wheel sets	CO7	L3
2	Hydrostatic bearing in high precision machine tools ,pad for automotive application,high-precision applications in measuring, testing and machine tool engineering	CO8	L3
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
1	A rectangular slider bearing with pivoted shoe has the following specification: Length of shoe=60mm Width of shoe=55mm Slider speed=5m/s Load=25kN Absolute viscosity=0.012Pas. Determine: (a)Minimum film thickness (b) Power loss due to viscous friction. Neglect side leakage.	C07	L3
2	Compare advantages and disadvantages of hydrodynamic and hydrostatic bearing.	C07	L3
3	What is the main difference between hydrodynamic and hydrostatic lubrication	C07	L3
4	Explain the working principle and applications of hydrodynamic thrust bearing	C07	L3
5	Write a note on thermal equilibrium of journal bearing	C07	L3
6	An oil ring full journal bearing is to operate in still air. The bearing diameter is 75 mm and length is 75 mm. Bearing is subjected to a load of 5 KN and is rotating at 500 rpm. Radial	C07	L3

	clearance is 0.0625 mm. The oil is SAE 30 and ambient temperature is 20 C. Determine the equilibrium temperature and viscosity of oil.		
7	Derive an expression for pressure distribution in plane slider bearing with fixed shoe	C07	L3
8	Derive an expression for load carrying capacity in plane slider bearing with fixed shoe	C07	L3
9	Derive an expression for pressure distribution in plane slider bearing with pivoted shoe	C07	L3
10	Derive an expression for load carrying capacity in plane slider bearing with pivoted shoe	CO8	L3
11	Derive an expression for center of pressure in plane slider bearing with fixed shoe	CO8	L3
12	Derive an expression for co-efficient of friction in plane slider bearing with pivoted shoe	CO8	L3
13	Derive an expression for center of pressure in plane slider bearing with fixed shoe	CO8	L3
14	Derive an expression for co-efficient of friction in plane slider bearing with pivoted shoe	CO8	L3
15	Explain hydro static lubrication	CO8	L3
16	Explain hydro static step bearings	CO8	L3
17	Derive an expression for load carrying capacity in hydro static step bearings	CO8	L3
18	Derive an expression for oil flow through hydro static step bearings	CO8	L3
19	A hydro static step bearing has the following data diameter of the shaft -150mm, dia of pocket-100mm,vertical thrust of bearing-$60*10^3$N,external pressure-1 atm,shaft speed-1500rpm,viscosity of lubricant -30cp,desirable oil thickness-0.0125cm.determine i)rate of flow ii)power loss due to friction iii)co- efficient of friction	CO8	L3
20	Rectangular plain slider bearing with fixed shoe with no end leakage has the following specifications Bearing length = 90mm, width of shoe = 90mm, Load on the bearing =7800N, Slider velocity = 250 cm/sec, Indination a = -0.00035 radians, visocity of oil at operating temperature = 40cp. Determine: i) Minimum Film thickness ii) Power loss iii) Co — efficient of friction.	5	CO2
21	pivoted shoe of the slider bearing has square shape. The load acting on the bearing is 13344N, velocity of the moving member is 5.08m/sec, and Lubricating oil is SAE 40. The expected mean temperature of oil is 90°C. Permissible minimum oil film thickness is 1.905 x10-5 m. Find i) Required dimensions of the shoe ii) Coefficient of friction under given operating conditions iii) Power loss. Assume inclination of surface corresponds to maximum load carrying capacity, Neglect the effect of end flow from the bearing.	C07	L3
22	Hydrostatic step bearing has following specifications shall diameter = 0.150m, Recess diameter = 0.100m, Vertical thrust load = 60kN, Speed of the shaft = 1500 rev/min, Viscosity of the lubricant is 30cp, Minimum oil film thickness = 1.25x104m. Determine: i) Discharge ii) Power loss due to viscous friction iii) coefficient of frication.	C07	L3
23	A hydro static step bearing has following specification: Shaft diameter = 130 mm, Pocket diameter = 55 mm, Shaft speed = 1800 rpm, Inlet pressure = 3.75 MPa, External pressure = 0, Expected oil temperature = 50°C Desirable oil film thickness = 0.00875 mm, Lubricating oil used = SAE60 ii) The rate of flow through bearing Determine : i) Load the bearing can support (10 Marks) iii) Power loss	C07	L3
24	Derive an expression for load carrying capcity of hydrostatic step bearing.	C07	L3
25	Distinguish a pivoted shoe slider bearing from a fixed shoe slider bearing.	C07	L3
26	Discuss locating center of pressure in fixed show slider bearing.	C07	L3
27	A pivoted shoe of the slider bearing has square shape. The load acting on the bearing is 13.34 kN velocity of the moving member is 5.08 m/sec. Lubricating oil is SAL 40. The expected mean temperature of oil film is 90°C. Permissible minimum oil film thickness is 1.905 x 10-5 m. Find: i) Required dimensions of the shoe ii) Coefficient of friction in the bearing under given operating condition iii) Power loss. Assume that inclination of surface corresponds to maximum load carrying capacity. Neglect effect of end flow of oil.	C07	L3
28	State the principles, advantages, disadvantages and applications of hydrostatic lubrication.	C07	L3
29	Explain the two main systems of hydrostatic lubrication.	C07	L3
30	A hydrostatic circular thrust bearing has the following data: Dia of pocket = 200 mm Shaft dia — 300 mm Pressure at the pocket = 500 kN/m/ Shaft speed 100 rpm Film thickness = 0.07 mm Viscosity of lubricant = 0.05 PaS.	C07	L3

	Determine: i) Load carrying capacity, ii) Oil flow rate, iii) Power loss due to friction.		
31	A hydrostatic step bearing for a turbine rotor has the following specifications : Diameter of shaft = 150mm ; Diameter of pocket = 100mm ; Vertical thrust of bearing = 70kN ; Shaft speed = 1000 rpm ; Viscosity of lubricant under operating condition = 0.025 fas — sec ; Desirable oil film thickness = 0.125mm. Determine i) Rate of oil flow through the bearing ii) Power loss due to viscous friction iii) co-efficient of friction.	C07	L3
32	A hydrostatic step bearing for a turbine rotor has the following specification :Diameter of shaft = 150 mm; diameter of pocket = 100 mm; vertical thrust = 70 kN; shaft speed = 1000 rpm; viscosity = 0.025 pa. sec; oil film thickness = 0.125 mm. Determine : i) Rate of oil flow through the bearing ii) Power loss due to viscous friction iii) Co-efficient of friction	C07	L3
33	A sider bearing with a rectangular pivoted shoe has the following specifications : Length of the shoe in the direction of motion = 75 mm Width of the shoe = 112.5 mm Velocity of moving member = 2 m/s Expected oil temperature = 70°C Permissible minimum film thickness = 0.0225 mm Lubricating oil used = SAE 40. Assuming the condition of bearing surface corresponds to maximum load carrying capacity of bearing. Determine : i) Load carrying capacity of bearing, ii) Power loss. Consider end leakage. Also calculate coefficient of friction.	C07	L3
34	Hydrostatic step bearing has the following specifications : Diameter of shaft = 150 mm Diameter of pocket = 100 mm Vertical thrust = 70 kN Shaft speed = 1000 rpm Viscosity of the lubricant = 0.025 PaS. Desirable oil film thickness = 0.125mm. Determine : i) Rate of flow through the bearing ii) Power loss due to viscous friction iii) Coefficient of friction.	C07	L3
e	**Experiences**	-	-
1		CO7	L2
2			
3			
4		CO8	L3
5			

E2. CIA EXAM – 2

a. Model Question Paper - 2

Crs Code:	15ME742	Sem:	VII	Marks:	30	Time:	75 minutes		
Course:	TRIBOLOGY								
-	-	**Note: Answer all questions, each carry equal marks. Module : 3, 4**					**Marks**	**CO**	**Level**
1	a	Define friction. State and explain friction theories					5	CO3	L2
	b	Explain measurement method for friction					5	CO3	L2
	c	Explain friction of metals and non metals					5	CO3	
		OR							
2	a	Explain mechanism of wear					5	CO4	L2
	b	Explain delamination theories					5	CO4	L2
	c	Explain debris analysis					5	CO4	L2
3	a	A rectangular slider bearing with pivoted shoe has the following specification: Length of shoe=60mm Width of shoe=55mm Slider speed=5m/s					8	CO7	L3

		Load=25kN Absolute viscosity=0.012Pas. Determine: (a)Minimum film thickness (b) Power loss due to viscous friction. Neglect side leakage.			
	b	Derive an expression for load carrying capacity and pressure distribution in plane slider bearing with fixed shoe	7	CO7	L3
		OR			
4	a	A hydro static step bearing has the following data diameter of the shaft -150mm dia of pocket-100mm vertical thrust of bearing-$60*10^3$N external pressure-1 atm shaft speed-1500rpm viscosity of lubricant -30cp desirable oil thickness-0.0125cm determine i)rate of flow ii)power loss due to friction iii)co- efficient of friction	7	CO8	L3
	b	Derive an expression for load carrying capacity oil flow through hydro static step bearings	8	CO8	L3

b. Assignment – 2

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	15ME742	Sem:	VII	Marks:	5	Time:	90 – 120 minutes
Course:	TRIBOLOGY				Module : 2, 4		
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1	1KT15ME	Define friction	5	CO4	L2
2	1KT15ME	State and explain friction theories	5	CO4	L2
3	1KT15ME	Explain measurement method for friction	5	CO4	L2
4	1KT15ME	Explain friction of metals and non metals	5	CO4	L2
5	1KT15ME	Define wear explain classification	5	CO4	L2
6	1KT15ME	Explain mechanism of wear	5	CO5	L2
7	1KT15ME	Explain delamination theories	5	CO5	L2
8	1KT15ME	Explain debris analysis	5	CO5	L2
9	1KT15ME	Explain testing methods and related standard to measurement of wear	5	CO5	L2
10	1KT15ME	Define friction	5	CO4	L2
11	1KT15ME	State and explain friction theories	5	CO4	L2
12	1KT15ME	Explain measurement method for friction	5	CO4	L2
13	1KT15ME	Explain friction of metals and non metals	5	CO4	L2
14	1KT15ME	Define wear explain classification	5	CO4	L2
15	1KT15ME	Explain mechanism of wear	5	CO5	L2
16	1KT15ME	Explain delamination theories	5	CO5	L2
17	1KT15ME	Explain debris analysis	5	CO5	L2
18	1KT15ME	Explain testing methods and related standard to measurement of wear	5	CO5	L2
19	1KT15ME	Define friction	5	CO4	L2
20	1KT15ME	State and explain friction theories	5	CO4	L2
21	1KT15ME	Explain measurement method for friction	5	CO4	L2
22	1KT15ME	Explain friction of metals and non metals	5	CO4	L2
23	1KT15ME	Define wear explain classification	5	CO4	L2
24	1KT15ME	Explain mechanism of wear	5	CO5	L2
25	1KT15ME	Explain delamination theories	5	CO5	L2
26	1KT15ME	Explain debris analysis	5	CO5	L2
27	1KT15ME	Explain testing methods and related standard to measurement of wear	5	CO5	L2
28	1KT15ME	A rectangular slider bearing with pivoted shoe has the following specification: Length of shoe=60mm Width of shoe=55mm Slider speed=5m/s	5	CO7	L3

		Load=25kN Absolute viscosity=0.012Pas. Determine: (a)Minimum film thickness (b) Power loss due to viscous friction. Neglect side leakage.			
29	1KT15ME	Compare advantages and disadvantages of hydrodynamic and hydrostatic bearing.	5	CO7	L3
30	1KT15ME	What is the main difference between hydrodynamic and hydrostatic lubrication	5	CO7	L3
31	1KT15ME	Explain the working principle and applications of hydrodynamic thrust bearing	5	CO7	L3
32	1KT15ME	Write a note on thermal equilibrium of journal bearing	5	CO7	L3
33	1KT15ME	An oil ring full journal bearing is to operate in still air. The bearing diameter is 75 mm and length is 75 mm. Bearing is subjected to a load of 5 KN and is rotating at 500 rpm. Radial clearance is 0.0625 mm. The oil is SAE 30 and ambient temperature is 20 ^{o}C. Determine the equilibrium temperature and viscosity of oil.	5	CO7	L3
34	1KT15ME	A hydro static step bearing has the following data diameter of the shaft -150mm dia of pocket-100mm vertical thrust of bearing-60*10^3N external pressure-1 atm shaft speed-1500rpm viscosity of lubricant -30cp desirable oil thickness-0.0125cm determine i)rate of flow ii)power loss due to friction iii)co- efficient of friction		CO7	L3
35	1KT15ME	Derive an expression for pressure distribution in plane slider bearing with fixed shoe	5	CO7	L3
36	1KT15ME	Derive an expression for load carrying capacity in plane slider bearing with fixed shoe	5	CO7	L3
37	1KT15ME	Derive an expression for pressure distribution in plane slider bearing with pivoted shoe	5	CO7	L3
38	1KT15ME	Derive an expression for load carrying capacity in plane slider bearing with pivoted shoe	5	CO7	L3
39	1KT15ME	Derive an expression for center of pressure in plane slider bearing with fixed shoe	5	CO7	L3
40	1KT15ME	Derive an expression for co-efficient of friction in plane slider bearing with pivoted shoe	5	CO7	L3
41	1KT15ME	Derive an expression for center of pressure in plane slider bearing with fixed shoe	5	CO7	L3
42	1KT15ME	Derive an expression for co-efficient of friction in plane slider bearing with pivoted shoe	5	CO7	L3
43	1KT15ME	Explain hydro static lubrication	5	CO8	L3
44	1KT15ME	Explain hydro static step bearings	5	CO8	L3
45	1KT15ME	Derive an expression for load carrying capacity in hydro static step bearings	5	CO8	L3
46	1KT15ME	Derive an expression for oil flow through hydro static step bearings	5	CO8	L3
	1KT15ME	Define friction	5	CO8	L3
47	1KT15ME	A hydro static step bearing has the following data diameter of the shaft -150mm dia of pocket-100mm vertical thrust of bearing-60*10^3N external pressure-1 atm shaft speed-1500rpm viscosity of lubricant -30cp desirable oil thickness-0.0125cm determine i)rate of flow ii)power loss due to friction iii)co- efficient of friction		CO8	L3
48	1KT15ME	State and explain friction theories		CO4	L2
49	1KT15ME	Explain measurement method for friction		CO4	L2
50	1KT15ME	Explain friction of metals and non metals	5	CO4	L2

51	1KT15ME	Define wear explain classification		CO4	L2
52	1KT15ME	Explain mechanism of wear		CO4	L2
53	1KT15ME	Explain delamination theories		CO5	L2
54	1KT15ME	Explain debris analysis		CO5	L2
55	1KT15ME	Explain testing methods and related standard to measurement of wear		CO5	L2
56	1KT15ME	A hydro static step bearing has the following data diameter of the shaft -150mm,dia of pocket-100mm vertical thrust of bearing-$60*10^3$N external pressure-1 atm shaft speed-1500rpm viscosity of lubricant -30cp desirable oil thickness-0.0125cm determine i)rate of flow ii)power loss due to friction iii)co- efficient of friction		C08	L3

D3. TEACHING PLAN - 3

Module – 5

Title:	Bearing Materials and Introduction to Surface engineering	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Understand bearing material properties and selection procedure	CO9	L2
2	principles of surface engineering for different applications of tribology	CO10	L2
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	-	-
23	Bearing Materials: Commonly used bearings materials	CO9	L2
24	properties of typical bearing materials.		
25	Advantages and disadvantages of bearing materials.	CO9	L2
26	Introduction to Surface engineering	CO10	L2
27	Concept and scope of surface engineering.		
28	Surface modification – transformation hardening,	CO10	L2
29	surface melting, thermo chemical processes.		
30	Surface Coating – plating, fusion processes, vapor phase processes.	CO10	L2
31	Selection of coating for wear and corrosion resistance.	CO10	L2
c	**Application Areas**	-	-
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	Stainless steel materials are used to make bearing components because it is more resistant to surface corrosion due to the higher content of chromium (~18%) with the addition of nickel. The material needs to be protected from corrosion with a coating of oil/grease (cages) or by plating (shields).	CO9	L2
2	Surface engineering techniques are being used in the automotive, aerospace, missile, power, electronic, biomedical, textile, petroleum, petrochemical, chemical, steel, cement, machine tools. Surface engineering techniques can be used to develop a wide range of functional properties, including physical, chemical, electrical, electronic, magnetic, mechanical, wear-resistant and corrosion-resistant properties at the required substrate surfaces. Almost all types of materials, including metals, ceramics, polymers, and composites can be coated on similar or dissimilar materials.	CO10	L2
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
1	Classify various bearing materials. Discuss their relative features	CO9	L2
2	Explain the properties of bearing materials	CO9	L2
3	Write advantages and dis advantages of bearing materials	CO9	L2

4	Write scope of surface engineering	CO9	L2
5	Explain surface modification	CO10	L2
6	Write a short note on transformation hardening	CO10	L2
7	Write a short note on surface melting	CO10	L2
8	Write a short note on thermo chemical engineering	CO10	L2
9	Write a short note on surface coating and plating	CO10	L2
10	Write a short note on on fusion processes and vapor phase processes	CO10	L2
11	Explain the procedure for selection coating for wear	CO10	L2
12	Explain corrosion resistance and how to prevent corrosion	CO10	L2
13	Write notes on i) Wear of ceramic materials ii) Wear measurements and iii) Effect of speed, temperature and pressure on wear.	CO10	L2
14	Briefly explain: i) Improved design and ii) Surface Engineering.	CO10	L2
15	List the commonly used bearing material and describe any of the five commonly with respect to their characteristics and advantages.	CO10	L2
16	List any ten desirable properties of typical bearing material and explain any of the five in portent properties in details	CO10	L2
17	Classify wear. Explain wear of polymer and ceramic materials.	CO10	L2
18	Explain the three tribological measures to reduce friction and wear.	CO10	L2
19	Explain with graphs the influence of speed, temperature and pressure on wear.	CO10	L2
20	What properties are expected of bearing materials? List them.	CO10	L2
21	What are conformability and embedability with respect to hearing materials? Explain.	CO10	L2
22	List the commonly used bearing materials. Explain any five of them with respect to their typical properties and advantages.	CO10	L2
22	Write explanatory notes on: Wear of ceramic materials Surface engineering Wear measurements Improved design of a tribological component Advanced material's use in tribology application.	CO10	L2
23	list the properties of good bearing materials. b. List out the commonly used bearing materials.	CO10	L2
24	List out the commonly used bearing materials.	CO10	L2
25	Give the classification of wear. Discuss in brief.	CO10	L2
26	Write short notes on wear of : i) Polymers ii) Ceramic materials.	CO10	L2
27	What are the technologies involved in surface engineering to improve tribological behavior of components.	CO10	L2
28	List any ten properties desirable for a typical bearing material	CO10	L2
29	Define wear. Discuss the different types of wear.	CO10	L2
30	Briefly discus behavior of tribological components.	CO10	L2
31	Briefly explain the improved design and surface engineering.	CO10	L2
32	explain any five desirable properties of a good bearing material.	CO10	L2
33	With neat sketches, explain different types of wear.	CO10	L2
34	Explain briefly : Wear measurement Improved design Material selection Surface engineering.	CO10	L2

E3. CIA EXAM – 3

a. Model Question Paper - 3

Crs Code:		15ME742	Sem:	VII	Marks:	30	Time:	75 minutes		
Course:		TRIBOLOGY								
-	-	**Note: Answer all questions, each carry equal marks. Module : 5**						**Marks**	**CO**	**Level**
1	a	Classify various bearing materials. Discuss their relative features						7	CO9	L1
	b	Explain the properties of bearing materials						8	CO9	L2
2	a	Write advantages and dis advantages of bearing materials						7	CO9	L2
	b	Explain surface modification						8	CO9	L4

3	a	Write a short note on on fusion processes and vapor phase processes	7	CO10	L1
	b	Explain corrosion resistance and how to prevent corrosion	8	CO10	L2
4	a	Write a short note on transformation hardening	7	CO10	L2
	b	Write a short note on surface melting	8	CO10	L2

b. Assignment – 3

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	15ME742	Sem:	VII	Marks:	5	Time:	90 – 120 minutes
Course:	TRIBOLOGY				Module : 5		
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1	1KT15ME	Classify various bearing materials. Discuss their relative features	5	CO9	L2
2	1KT15ME	Explain the properties of bearing materials	5	CO9	L3
3	1KT15ME	Write advantages and dis advantages of bearing materials		CO10	L4
4	1KT15ME	Write scope of surface engineering	5	CO10	L3
5	1KT15ME	Explain surface modification		CO10	L4
6	1KT15ME	Write a short note on transformation hardening		CO10	L4
7	1KT15ME	Write a short note on surface melting		CO10	L4
8	1KT15ME	Write a short note on thermo chemical engineering		CO10	L4
9	1KT15ME	Write a short note on surface coating and plating		CO10	L4
10	1KT15ME	Write a short note on on fusion processes and vapor phase processes		CO10	L4
11	1KT15ME	Explain the procedure for selection coating for wear		CO10	L4
12	1KT15ME	Explain corrosion resistance and how to prevent corrosion		CO10	L4
13	1KT15ME	Classify various bearing materials. Discuss their relative features		CO9	L2
14	1KT15ME	Explain the properties of bearing materials		CO9	L2
15	1KT15ME	Write advantages and dis advantages of bearing materials			
16	1KT15ME	Write scope of surface engineering		CO10	L4
17	1KT15ME	Explain surface modification		CO10	L4
18	1KT15ME	Write a short note on transformation hardening		CO10	L4
19	1KT15ME	Write a short note on surface melting		CO10	L4
20	1KT15ME	Write a short note on thermo chemical engineering		CO10	L4
21	1KT15ME	Write a short note on surface coating and plating		CO10	L4
22	1KT15ME	Write a short note on on fusion processes and vapor phase processes		CO10	L4
23	1KT15ME	Explain the procedure for selection coating for wear		CO10	L4
24	1KT15ME	Explain corrosion resistance and how to prevent corrosion		CO10	L4
25	1KT15ME	Classify various bearing materials. Discuss their relative features		CO9	L2
26	1KT15ME	Explain the properties of bearing materials		CO9	L2
27	1KT15ME	Write advantages and dis advantages of bearing materials		CO9	L2
28	1KT15ME	Write scope of surface engineering		CO10	L4
29	1KT15ME	Explain surface modification		CO10	L4
30	1KT15ME	Write a short note on transformation hardening		CO10	L4
31	1KT15ME	Write a short note on surface melting		CO10	L4
32	1KT15ME	Write a short note on thermo chemical engineering		CO10	L4
33	1KT15ME	Write a short note on surface coating and plating		CO10	L4
34	1KT15ME	Write a short note on on fusion processes and vapor phase processes		CO10	L4
35	1KT15ME	Explain the procedure for selection coating for wear		CO10	L4
36	1KT15ME	Explain corrosion resistance and how to prevent corrosion		CO10	L4
37	1KT15ME	Classify various bearing materials. Discuss their relative features		CO9	L2
38	1KT15ME	Explain the properties of bearing materials		CO9	L2
39	1KT15ME	Write advantages and dis advantages of bearing materials		CO9	L2
40	1KT15ME	Write scope of surface engineering		CO10	L4
41	1KT15ME	Explain surface modification		CO10	L4
42	1KT15ME	Write a short note on transformation hardening		CO10	L4
43	1KT15ME	Write a short note on surface melting		CO10	L4
44	1KT15ME	Write a short note on thermo chemical engineering		CO10	L4
45	1KT15ME	Write a short note on surface coating and plating		CO10	L4
46	1KT15ME	Write a short note on on fusion processes and vapor phase processes		CO10	L4

46	1KT15ME	Explain the procedure for selection coating for wear		CO10	L4
47	1KT15ME	Explain corrosion resistance and how to prevent corrosion		CO10	L4

F. EXAM PREPARATION

1. University Model Question Paper

Course:		TRIBOLOGY					Month / Year		May /2018
Crs Code:		15ME742	Sem:	VII	Marks:	80	Time:		180 minutes
Module	**Note**	Answer all FIVE full questions. All questions carry equal marks.					**Marks**	**CO**	**Level**
1	a	Explain practical importance of tribology					4	CO1	L2
	b	Explain application of tribology in various fields					8		L2
	c	Explain standard grades of lubricant					4	CO2	L2
									L2
		OR							L2
-	a	Explain the properties of lubricants					4	CO1	L2
	b	Define viscosity. state the law of viscosity					8	CO2	L2
	c	Explain the method of measurement of viscosity					4		L2
2	a	State and explain friction theories					4	C03	L2
	b	Explain measurement method for friction					8		L2
	c	Explain friction of metals and non metals					4	CO4	L2
									L2
		OR							L2
-	a	Define wear explain classification					4	CO3	L2
	b	Explain mechanism of wear					4	CO4	L2
	c	Explain delamination theories					4		L2
	d	Explain debris analysis					4		L2
3	a	Derive expression for frictional force and power loss in lightly loaded journals bearings					4	CO5	L4
	b	Explain the mechanism of pressure development in oil film					6		L4
	c	Derive an expression for Reynold's equation in 2-d					6	CO6	L4
		OR							L4
-	a	Derive expression for load carring capacity of idealized journal bearings					4	CO5	L4
	b	A full journals bearings have a specification, shaft diameter 4.5cms,bearing length 6.5cms, radial clearance ratio is 0.0015, speed 2800rpm, radial load 800N, viscosity of lubricant at effective, temperature of oil 1.2*10^{-}6Reyn, consider bearings as a lightly loaded , determine i)frictional torque at the shaft ii)co-efficient of friction iii)power loss					8		L4
	c	Explain sommerfeld's number and it;s significance					4	CO6	L4
4	a	Derive an expression for pressure distribution in plane slider bearing with fixed shoe					6	CO7	L3
	b	Derive an expression for load carrying capacity in plane slider bearing with pivoted shoe					6		L3
	c	A rectangular slider bearing with pivoted shoe has the following specification: Length of shoe=60mm Width of shoe=55mm Slider speed=5m/s Load=25kN Absolute viscosity=0.012Pas. Determine: (a)Minimum film thickness (b) Power loss due to viscous friction. Neglect side leakage.					4	C08	L3

					L3
		OR			L3
-	a	Derive an expression for load carrying capacity in hydro static step bearings	4	CO7	L3
	b	Derive an expression for oil flow through hydro static step bearings	6	CO8	L3
	c	A hydro static step bearing has the following data diameter of the shaft -150mm dia of pocket-100mm vertical thrust of bearing-$60*10^3$N external pressure-1 atm shaft speed-1500rpm viscosity of lubricant -30cp desirable oil thickness-0.0125cm determine i)rate of flow ii)power loss due to friction iii)co- efficient of friction	6		L3
					L2
5	a	Classify various bearing materials. Discuss their relative features	4	CO9	L2
	b	Explain the properties of bearing materials	6	CO10	L2
	c	Write advantages and dis advantages of bearing materials	6		L2
					L2
		OR			L2
	a	Write a short note on thermo chemical engineering	4	CO9	L2
	b	Write a short note on surface coating and plating	4		L2
	c	Write a short note on on fusion processes and vapor phase processes	4	C010	L2
	d	Explain the procedure for selection coating for wear	4		L2

2. SEE Important Questions

Course:		TRIBOLOGY					Month / Year	May /2018	
Crs Code:		15ME742	Sem:	7	Marks:	80	Time:	180 minutes	
	Note	Answer all FIVE full questions. All questions carry equal marks.					-	-	
Module	Qno.	Important Question					**Marks**	**CO**	**Year**
1	1	Sketch and explain working of any two viscosity measuring apparatus types. Explain historical background of tribology					16	CO2	2010
	2	Explain practical importance of tribology,Explain standard grades of lubricant						CO1	2008
	3	Explain application of tribology in various fields						CO1	2009
	4	Define lubrication,viscosity. state the law of viscosity,Explain types and application of lubricants						CO2	
	5								
2	1	State and explain friction theories, Explain measurement method for friction					16	CO3	2011
	2	Explain friction of metals and non metals, Define wear explain classification						CO3	2008
	3	Explain mechanism of wear, Explain delamination theories						CO4	
	4	Explain debris analysis						CO4	
	5	Explain testing methods and related standard to measurement of wear						CO3	
3	1	Explain sommerfeld's number and it;s significance					16	CO6	
	2	Explain end leakages in journals bearings						CO6	
	3	Explain and derive petroff's equation						CO5	2009
	4	Explain the mechanism of pressure development in oil film						CO5	
	5	Design a journal bearing with the following specifications: Journal diameter=100mm Journal speed=3000rpm Radial load=15kN.						CO5	2008
		Design a journal bearing with the following specifications Journal diameter = 200						CO6	2010

		Diametrical clearance ratio temperature operation pm load on piston = 80 KN, Engine speed = 200 rpm, 9 Determine heat generated and heat disipiated, given bient temperature = 25°C, Attitude = 0.8, Absolute , assume as square bearing. (1) Power loss (i) Coefficient of friction.			
4	1	Derive an expression for pressure distribution in plane slider bearing with fixed shoe	16	CO7	2004
	2	Derive an expression for load carrying capacity in plane slider bearing with pivoted shoe		CO7	2004
	3	Hydro static step bearing has the following data diameter of the shaft -150mm dia of pocket-100mm vertical thrust of bearing-60*10^3N external pressure-1 atm shaft speed-1500rpm viscosity of lubricant -30cp desirable oil thickness-0.0125cm determine i)rate of flow ii)power loss due to friction iii)co- efficient of friction		CO8	2006
	4	A rectangular slider bearing with pivoted shoe has the following specification: Length of shoe=60mm Width of shoe=55mm Slider speed=5m/s Load=25kN Absolute viscosity=0.012Pas. Determine: (a)Minimum film thickness (b) Power loss due to viscous friction. Neglect side leakage.	CO7		2004
	5	Derive an expression for load carrying capacity and oil flow through in hydro static step bearings.	CO8		2007
5	1	Classify various bearing materials. Discuss their relative features	16		2009
	2	Explain the properties of bearing materials	CO9		2007
	3	Write advantages and dis advantages of bearing materials	CO9		
	4	Write scope of surface engineering, explain surfaces modification	CO10		2009
	5	Write a short note on transformation hardening and surface melting	CO10		2007
	6	Write a short note on surface melting	CO10		
	7	Write a short note on thermo chemical engineering surface coating and plating fusion processes and vapor phase processes	CO10		2009
	8	Explain the procedure for selection coating for wear	CO9		2007
	9	Explain corrosion resistance and how to prevent corrosion	CO9		

G. Content to Course Outcomes

1. TLPA Parameters

Table 1: TLPA – Example Course

Module- #	Course Content or Syllabus (Split module content into 2 parts which have similar concepts)	Content Teaching Hours	Blooms' Learning Levels for Content	Final Blooms' Level	Identified Action Verbs for Learning	Instruction Methods for Learning	Assessment Methods to Measure Learning
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
1	**Introduction to Tribology:** Historical background, practical importance, and subsequent use in the field.	4	L2 understand	L2	- understand - Tribological properties	- Lecture - -	- Slip Test - -
1	**Lubricants**: Types and specific field of applications.	4	L2	L4	understand	- Lecture	- Assignment

	Properties of lubricants, viscosity, its measurement, effect of temperature and pressure on viscosity, lubrication types, standard grades of lubricants, and selection of lubricants.		understand		Tribological parameters	- Tutorial -	- -
2	**Friction:** Origin, friction theories, measurement methods, friction of metals and non-metals.	4	L2 understand	L2	-understand -friction	- Lecture -	- Assignment -
2	**Wear:** Classification and mechanisms of wear, delamination theory, debris analysis, testing methods and standards. Related case studies.	4	L2 understand	L4	-understand -	- Lecture -	- Slip Test -
3	**Hydrodynamic journal bearings:** Friction forces and power loss in a lightly loaded journal bearing,Petroff's equation, mechanism of pressure development in an oil film, and Reynold's equation in 2D.	5	L4 Analyse	L4	-anlyze -Lightly loaded journal bearing analysis	- Lecture -	- Slip Test -
3	**Introduction to idealized journal bearing,** load carrying capacity, condition for equilibrium,Sommerfeld's number and it's significance; partial bearings, end leakages in journal bearing, numerical examples on full journal bearings only.	5	L4 Analyse	L4	-anlyze -Full journal bearing analysis	- Lecture - Tutorial -	- Assignment - -
4	**Plane slider bearings with fixed/pivoted shoe:** Pressure distribution, Load carrying capacity, coefficient of friction, frictional resistance in a fixed/pivoted shoe bearing, center of pressure, numerical examples.	4	L3 apply	L3	--anlyze -Plane slider bearings analysis	- Lecture - Tutorial -	- Assignment - -
4	**Hydrostatic Lubrication**: Introduction to hydrostatic lubrication, hydrostatic step bearings, load carrying capacity and oil flow through the hydrostatic step bearing, numerical examples	4	L3 apply	L2	--anlyze - hydrostatic step bearings analysis	- Lecture - Tutorial -	- Assignment - -
5	**Bearing Materials:** Commonly used bearings materials, and properties of typical bearing materials. Advantages and disadvantages of bearing materials. Introduction to Surface engineering: Concept and scope of surface engineering.	4	L2 understand	L2	-understand -Bearing Materials properties	- Lecture -	- Assignment - -
5	**Surface modification** – transformation hardening, surface melting, thermo chemical processes. **Surface Coating – plating, fusion processes, vapor phase processes. Selection of coating for wear and corrosion resistance.**	4	L2 understand	L2	-understand -surface engineering	- Lecture -	- Assignment - -

2. Concepts and Outcomes:

Table 2: Concept to Outcome – Example Course

Module- #	Learning or Outcome from study of the Content or Syllabus	Identified Concepts from Content	Final Concept	Concept Justification (What all Learning Happened from the study of Content / Syllabus. A short word for learning or outcome)	CO Components (1.Action Verb, 2.Knowledge, 3.Condition / Methodology, 4.Benchmark)	Course Outcome **Student Should be able to ...**
A	*I*	*J*	*K*	*L*	*M*	*N*

1	Understand the fundamentals of tribology	Tribological properties	Tribological properties	Understand the fundamentals of tribology	-understand -Tribological properties	Understand the fundamentals of tribology
1	Understand the parameters associated with tribology	Tribological parameters	Tribological parameters	Understand the parameters associated with tribology	understand Tribological parameters	Understand the parameters associated with tribology
2	Understand the concepts of tribological components experiencing the relative motion	friction	friction	Understand the concepts of tribological components experiencing the relative motion	-understand -friction	Understand the concepts of tribological components experiencing the relative motion
2	Understand the concepts of contact mechanism involved in relative motion	Contact mechanism	Contact mechanism	Understand the concepts of contact mechanism involved in relative motion	-understand -	Understand the concepts of contact mechanism involved in relative motion
3	Analyze requirements for design a lightly load journal bearings	Lightly loaded journal bearing analysis	Lightly loaded journal bearing analysis	Analyze requirements for design a lightly load journal bearings	-anlyze -Lightly loaded journal bearing analysis	Analyze requirements for design a lightly load journal bearings
3	Analyze terminology of full journal bearing	Full journal bearing analysis	Full journal bearing analysis	Analyze terminology of full journal bearing	-anlyze -Full journal bearing analysis	Analyze terminology of full journal bearing
4	Apply the performance characteristics of bearing in design of plane slider bearing	Plane slider bearings analysis	Plane slider bearings analysis	Apply the performance characteristics of bearing in design of plane slider bearing	--anlyze -Plane slider bearings analysis	Apply the performance characteristics of bearing in design of plane slider bearing
4	Apply concepts of hydro static lubrication for design a step bearing	hydrostatic step bearings analysis	hydrostatic step bearings analysis	Apply concepts of hydro static lubrication for design a step bearing	--anlyze -hydrostatic step bearings analysis	Apply concepts of hydro static lubrication for design a step bearing
5	Understand bearing material properties and selection procedure	Bearing Materials properties	Bearing Materials properties	Understand bearing material properties and selection procedure	-understand -Bearing Materials properties	Understand bearing material properties and selection procedure
5	Understand principles of surface engineering for different applications of tribology	surface engineering	surface engineering	Understand principles of surface engineering for different applications of tribology	-understand -surface engineering	Understand principles of surface engineering for different applications of tribology