Ref No:

< SRI KRISHNA INSTITUTE OF TECHNOLOGY, BENGALURU>

COURSE PLAN

Academic Year 2019-20

Program:	B E – Mechanical Engineering
Semester :	5
Course Code:	17ME53
Course Title:	Turbo Machines
Credit / L-T-P:	4 / 3-2-0
Total Contact Hours:	50
Course Plan Author:	B.M.Krishne Gowda

Academic Evaluation and Monitoring Cell

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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

17ME43: TURBO MACHINES

A. COURSE INFORMATION

1. Course Overview

Degree:	BE	Program:	ME
Semester:	5	Academic Year:	2019-20
Course Title:	TURBO MACHINES	Course Code:	17ME53
Credit / L-T-P:	4 / 3-2-0	SEE Duration:	180 Minutes
Total Contact Hours:	50 Hours	SEE Marks:	60 Marks
CIA Marks:	40 Marks	Assignment	1 / Module
Course Plan Author:	B.M.KRISHNE GOWDA	Sign ..	Dt:
Checked By:		Sign ..	Dt:
CO Targets	CIA Target : 80 %	SEE Target:	70.00%

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:** Definition of turbo machine, parts of turbo machines, Comparison with positive displacement machines, Classification, Dimensionless parameters and their significance, Effect of Reynolds number, Unit and specific quantities, model studies. (Note: Since dimensional analysis is covered in Fluid Mechanics subject, questions on dimensional analysis may not be given. However, dimensional parameters and model studies may be given more weightage.) **Thermodynamics of fluid flow:** Application of first and second law of thermodynamics to turbo machines, Efficiencies of turbo machines, Static and Stagnation states, Incompressible fluids and perfect gases, overall isentropic efficiency, stage efficiency (their comparison) and polytropic efficiency for both compression and expansion processes. Reheat factor for expansion process	10 (5,5)	Definition for TM Dimensionless parameters. Efficiency Reheat factor model studies	Understand L2, L3
2	Energy exchange in Turbo machines: Euler's turbine equation, Alternate form of Euler's turbine equation, Velocity triangles for different values of degree of reaction, Components of energy transfer, Degree of Reaction, utilization factor, Relation between degree of reaction and Utilization factor, Problems. General Analysis of Turbo machines: Radial flow compressors and pumps – general analysis, Expression for degree of reaction, velocity triangles, Effect of blade discharge angle on energy transfer and degree of reaction, Effect of blade discharge angle on performance, Theoretical head – capacity relationship, General analysis of axial flow pumps and compressors, degree of reaction, velocity triangles, Problems. 10 Hours	10 (5, 5)	Velocity triangle. Work done and energy transfer	L3 L3
3	Steam Turbines: Classification, Single stage impulse turbine, condition for maximum blade efficiency, stage efficiency, Need and methods of compounding, Multi-stage impulse turbine, expression for maximum	10 (5, 5)	Enthalpy change. stage efficiencies	Understand L3 Understand L3,

	utilization factor. Reaction turbine – Parsons's turbine, condition for maximum utilization factor, reaction staging. Problems.			
4	Hydraulic Turbines: Classification, various efficiencies. Pelton turbine – velocity triangles, design parameters, Maximum efficiency. Francis turbine - velocity triangles, design parameters, runner shapes for different blade speeds. Draft tubes- Types and functions. Kaplan and (10 Hours) Propeller turbines - velocity triangles, design parameters. Problems.	10 (4, 6)	Efficiency, design parameters.	Understand L3, Understand L3
5	Centrifugal Pumps: Classification and parts of centrifugal pump, different heads and efficiencies of centrifugal pump, Minimum speed for starting the flow, Maximum suction lift, Net positive suction head, Cavitation, Need for priming, Pumps in series and parallel. Problems. Centrifugal Compressors: Stage velocity triangles, slip factor, power input factor, Stage work, Pressure developed, stage efficiency and surging and problems. Axial flow Compressors: Expression for pressure ratio developed in a stage, work done factor, efficiencies and stalling. Problems.	10 (5, 5)	Power , work done factor, Efficiency.	Understand L3 Understand L3
-	**Total**	**50**		-

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.)**	-	-
1,2,3,4,5	1. An Introduction to Energy Conversion, Volume III, Turbo machinery, V. Kadambi and Manohar Prasad, New Age International Publishers, reprint 2008.	1, 2 3, 5	In Lib/ In dept.Lib
1,2,3,4,5	2.Turbines, Compressors & Fans, S. M. Yahya, Tata McGraw Hill Co. Ltd., 2nd edition, 2002	1, 2, 4,5	In Lib/ In dept.Lib
B	**Reference books (Title, Authors, Edition, Publisher, Year.)**	-	-
1,2,3,4,5	1.Principals of Turbo machines, D. G. Shepherd, The Macmillan Company (1964).	1, 2, 3,4,5	In Lib.
1,2,3,4,5	2.Fluid Mechanics & Thermodynamics of Turbo machines, S. L. Dixon, Elsevier (2005).	1, 2, 3,4,5	In Lib.
1,2,3,4,5	3.Text Book of Turbo machines, M. S. Govindegouda and A. M. Nagaraj, M. M. Publications, 4Th Ed, 2008		In Lib.
C	**Concept Videos or Simulation for Understanding**	-	-
C1	https://www.youtube.com/watch time= 7 min		
C2	https://www.youtube.com/watch?v=1tzToTrmzAk ,time= 6 min		
C3	https://www.youtube.com/watch?v=8Epf3U7WCZQ		
C4	https://nptel.ac.in/courses/112106200/		
C5	https://www.youtube.com/watch?v=8mnB7JGQ_CI		
C6	https://nptel.ac.in/courses/112103248/13 -1Hour 1 min		
D	**Software Tools for Design**	-	-

E	**Recent Developments for Research**	-	-

F	**Others (Web, Video, Simulation, Notes etc.)**	-	-
1	https://lecturenotes.in/materials/24627-notes-for-turbomachine		
2	http://web.iitd.ac.in/~pmvs/course_mel346.php		

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	17ME33	Basics of thermodynamics	1. Knowledge on basic laws and thermodynamic process	3	----	L2
2	17ME44	Fluid mechanics	Working principles of turbines ,pumps and compressors and dimensional techniques.	4	GAP -- Seminar on Fluid Machines.	L3

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	Fluid Machines / Knowledge of advanced Machines	Higher Study	Gap -A seminar on Fluid Machines	Understand L3
2	CFD	Applications in industries	Gap---Software tools	Understand L3

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	17ME53.1	Understanding the parameters of fluid machines using dimensional method and calculate by dimensional technique.	4	Precise definition of TM and model studies	Lecture	Assignment, Unit Test & CIE	L2 Understand
1	17ME53.2	Understanding the efficiency for different process and find it by using principles of thermodynamics.	6	Efficiency of processes.	Lecture	Assignment, Unit Test & CIE	L2 Understand
2	17ME53.3	Understanding the components of energy transfer and find energy transfer and dor using velocity triangles.	4	Energy transfer	Lecture	Assignment, Unit Test & CIE	L2 Understand
2	17ME53.4	Understanding the of working principles and find work done and dor for pumps and compressors using velocity triangles.	6	Enthalpy change	Lecture	Assignment, Unit Test & CIE	L2 Understand
3	17ME53.5	Understanding work done, efficiency of the single and multistage steam impulse type turbine and find these using velocity triangles graphical method.	4	Power and efficiencies of impulse	Lecture	Assignment, Unit Test & CIE	L2 Understand

3	17ME53.6	Understanding work done efficiency the steam reaction type turbine and find these using velocity triangles. graphical method.	6	Power and efficiencies of reaction type	Lecture	Assignment, Unit Test & CIE	L2 Understand
4	17ME53.7	understanding the working principles Pelton turbine and determine the Design parameters using velocity triangles analytical method.	5	Work done	Lecture	Assignment, Unit Test & CIE	L2 Understand
4	17ME53.8	Understanding the working principles of Francis turbine, Kaplan turbine and determine the Design parameters of these using velocity triangles by analytical method.	5	Power and Efficiency	Lecture	Assignment, Unit Test & CIE	L2 Understand
5	17ME53.9	Explains the working and efficiencies of Centrifugal Pump and find these by analytical method.	5	Work done and efficiencies	Lecture	Assignment, Unit Test , & CIE	L2 Understand
5	17ME53.10	Explains the working and efficiencies of Centrifugal and axial compressors and find these by analytical method..	5	Power and stage efficiencies	Lecture	Assignment unit test& CIE	L2 Understand
-	**-**	**Total**	**50**		**-**	**-**	**L2-L2**

2. Course Applications

Write 1 or 2 applications per CO.
Students should be able to employ / apply the course learning's to . . .

Modules	Application Area Compiled from Module Applications.	CO	Level
1	In research and development organizations in the analysis of model and prototype. (G.T.R.E)	CO1	L2
2	n research and development organizations for predicting the parameters for analysis of actual TM.	CO2	
3	In research and development organizations for predicting the parameters for analysis of actual turbines.	CO3	L2
4	In research and development organizations for predicting the parameters for analysis of actual fluid machines	CO4	L3
5	Power generation in steam power plant	CO5	L2
6	Power generation in steam power plant	CO6	L3
7	Power generation in hydraulic power plant	CO7	L3
8	Power generation in hydraulic power plant	CO8	L3
9	Water well pumps and inclined mounted pumps.	CO9	L3
10	Refrigeration and air conditioning technology.	CO10	L3

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	1	'Engineering Knowledge:' - The knowledge of fluid parameters is required to accomplish solution in designing fluid machines.	L2
1	CO1	PO2	2	Engineering Knowledge:' -Anlysing problems of fluid machines using dimensional technique.	L2
1	CO1	PO3	3	Engineering- Acquisition of Engineering Knowledge of basic of fluid parameters and dimensional methods is essential to accomplish solutions to complex engineering problems in design of turbines	L3
1	CO2	PO1	1	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of principles of TD is essential to accomplish solutions to complex engineering problems in fluid machines..	L2
1	CO2	PO2	2	Engineering Knowledge:' - Anlysing problems of fluid machines using efficiency	L2

				for different process.	
1	CO2	PO3	3	Engineering Knowledge:' - To the development of solutions or to design solutions for complex problem and efficiency for different process and principles of thermodynamics are considered	L3
2	CO3	PO1	1	Problem Analysis': The knowledge of energy transfer of fluid machines and DOR is required for the solution of problems.	L2
2	CO3	PO2	2	Engineering Knowledge:' - Anlysing problems of fluid machines using velocity triangles.	L3
2	CO3	PO3	3	Engineering Knowledge:' -To the development of solutions or to design solutions for complex problems energy transfer and dor' using velocity triangles. are considered.	L2
2	CO4	PO1	1	The knowledge of working principle and work done required for the solution of problems related to power absorbing machines	L2
2	CO4	PO2	2	Anlysing problems of fluid machines using velocity triangles.	L2
2	CO4	PO3	3	To the development of solutions or to design solutions for complex problems working principles , work done and dor for pumps and compressors using velocity triangles are considered.	L3
3	CO5	PO1	1	The knowledge of work done, efficiency of the single and multistage steam impulse type turbine is required for the solution of problems related to impulse turbine.	L2
3	CO5	PO2	2	Anlysing problems of fluid machines using velocity triangles	L2
3	CO5	PO3	3	To the development of solutions or to design solutions for complex problems work done, efficiency of the single and multistage steam impulse type turbine and using velocity triangle are considered.	L3
3	CO6	PO3	3	The knowledge of work done and efficiency is required for the solution of problems.	L2
4	CO7	PO1	1	Analysis of problems of fluid machines using velocity triangles	L2
4	CO7	PO2	2	To the development of solutions or to design solutions for complex problems work done, efficiency of the steam reaction type turbine using velocity triangles are considered.	L3
4	CO7	PO3	3	The knowledge of working principles is required for the solution of problems relatet to impulse machines.	L2
4	CO8	PO1	1	The working principles of fluid machines of reaction type is required for the solution of problems.	L2
4	CO8	PO2	2	Anlysing problems of fluid machines using dimensional technique.	L2
4	CO8	PO3	3	To the development of solutions or to design solutions for complex problems working principles and velocity triangles are considered.	L2
5	CO9	PO1	1	The knowledge of working of fluid machines related to centrifugal flow pump is required for the solution of problems.	L2
5	CO9	PO2	2	Anlysing problems of fluid machines using velocity triangles.	L2
5	CO9	PO3	3	To the development of solutions or to design solutions for complex problems both working principles and velocity triangles are considered.	L3
5	CO10	PO1	1	The knowledge of working of fluid machines related to compressors of centrifugal and axial type is required for the solution of problems.	L2
5	CO10	PO2	2	Anlysing problems of fluid machines using velocity triangles.	L2
5	CO10	PO3	3	To the development of solutions or to design solutions for complex problems both working principles and efficiencies and velocity triangles are considered.	L3

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	17ME53.1	Students should be able to Understanding the parameters of fluid machines using dimensional method and calculate by dimensional technique.	√	√	√	-	-	-	-	-	-	-	-	-	-	-	-	L2
1	17ME53.2	Students should be able to Understanding the efficiency for	√	√	√	-	-	-	-	-	-	-	-	-	-	-	-	L3

		different process and find it by using principles of thermodynamics.																
2	17ME53.3	Students should be able to Understanding the components of energy transfer and find energy transfer and dor using velocity triangles.	√	√	√	-	-	-	-	-	-	-	-	-	-	-	-	L2
2	17ME53.4	Students should be able to Understanding the of working principles and find work done and dor for pumps and compressors using velocity triangles.	√	√	√	-	-	-	-	-	-	-	-	-	-	-	-	L3
3	17ME53.5	Students should be able to Understanding work done, efficiency of the single and multistage steam impulse type turbine and find these using velocity triangles graphical method.	√	√	√	-	-	-	-	-	-	-	-	-	-	-	-	L3
3	17ME53.6	Students should be able to Understanding work done efficiency the steam reaction type turbine and find these using velocity triangles. graphical method.	√	√	√	-	-	-	-	-	-	-	-	-	-	-	-	L3
4	17ME53.7	Students should be able to understanding the working principles Pelton turbine and determine the Design parameters using velocity triangles analytical method.	√	√	√	-	-	-	-	-	-	-	-	-	-	-	-	L3
4	17ME53.8	Students should be able to Understanding the working principles of Francis turbine, Kaplan turbine and determine the Design parameters of these using velocity triangles by analytical method.	√	√	√	-	-	-	-	-	-	-	-	-	-	-	-	L3
5	17ME53.9	Students should be able to explains the working and efficiencies of Centrifugal Pump and find these by analytical method.	√	√	√	-	-	-	-	-	-	-	-	-	-	-	-	L3
5	17ME53.10	Students should be able to explains the working and efficiencies of Centrifugal and axial compressors and find these by analytical method..	√	√	√	-	-	-	-	-	-	-	-	-	-	-	-	L3
-	**17ME53**	**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

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	Automated machine tools	Placement, GATE, Higher Study, Entrepreneurship.	Presentation	17th May 2019	Mr. Hanumatharaju, Dynamatic Industries	PO1

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 and Thermodynamics of fluid flow	10	2	-	-	1	1	2	CO1, CO2	L2, L3
2	Energy exchange in Turbo machines. . General Analysis of Turbo machines	10	2	-	-	1	1	2	CO3, CO4	L2, L3
3	Steam Turbines and Reaction turbine	10	-	-	2	1	1	2	CO5, CO6	L2, L3
4	Hydraulic Turbines and Francis turbine	10	-	2	2	1	1	2	CO7, C08	L3, L3
5	Centrifugal Pump and Centrifugal Compressor	10	-	2	2	1	1	2	CO9, CO10	L3, L3
-	**Total**	**50**				**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	30	CO1, CO2, CO3,Co4	L2,L3,L2,L3
3, 4	CIA Exam – 2	30	CO7, C08, CO9, CO10	L2,L3,L2,L3
5	CIA Exam – 3	30	CO5, CO6,	L2,L2
1, 2	Assignment - 1	10	CO1, CO2, CO3,Co4	L2,L2,L2,L2
3, 4	Assignment - 2	10	CO7, C08, CO9, CO10	L2,L2,L2,L3
5	Assignment - 3	10	CO5, CO6,	L2,L3
1, 2	Seminar - 1		-	-
3, 4	Seminar - 2		-	-
5	Seminar - 3		-	-
1, 2	Quiz - 1		-	-
3, 4	Quiz - 2		-	-
5	Quiz - 3		-	-
1 - 5	Other Activities – Mini Project	-	CO9, CO10	L2,L3
	Final CIA Marks	**40**	**-**	**-**

D1. TEACHING PLAN - 1

Module - 1

Title:	Introduction and TD fluid flow	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	Able to give precise definition of turbo machinery	-	**Level**
1	Identify various types of turbo machinery	CO1	L2
2	Analyze the performance of turbo machinery.	CO2	L2
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	**-**	**-**
1	Introduction Definition of turbo machine, parts of turbo machines, Comparison with positive displacement machines, Classification,	C01	L2
2	Dimensionless parameters and their significance, Effect of Reynolds number,	C01	L2
3	Unit and specific quantities,	C01	L2
4	model studies.	C01	L2
5	problems	C01	L2
6	Thermodynamics of fluid flow: Application of first and second law of thermodynamics to turbo machines,	C02	L3
7	Efficiencies of turbo machines, Static and Stagnation states, Incompressible fluids and perfect gases, overall isentropic efficiency	C02	L3
8	stage efficiency (their comparison) and polytropic efficiency for both compression and expansion processes.	C02	L3
9	Reheat factor for expansion process	C02	L3
10	problems	C02	L3
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	In research and development organizations in the analysis of model and prototype. (G.T.R.E)Machine tools are used to remove extra materials from the work	CO1	L2
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
1	Define Turbo machines.	CO1	L2
2	With neat sketch explain the parts of a Turbo machines.	CO1	L2
3	What are the classification of Turbo machines?	CO1	L2
4	Wat are the differences between positive displacement machines and turbo machines?	CO1	L2
5	Explain the effect of Reynold number on the performance analysis of turbo machines..	CO1	L2
6	Explain the significance of flow coefficient, head coefficient and power coefficient with equations.	CO1	L2
7	Two geometrically similar pumps are running at the same speed of 1000 rpm. One pump hasan impeller diameter of 0.3 m and lifts water at rate of 20 es against a head of 15 m.Determine the head and impeller diameter of other pump to deliver half the discharge.	CO1	L3
8	Define the following for a compression process : (i) Total to total efficiency (ii) Static to static efficiency	CO2	L3
9	What is Reheat factor? Show that the reheat factor is greater than unity in multistage turbine	CO2	L3
10	Explain static and stagnation state for a fluid. Obtain an expression relating static and stagnation temperature for a perfect gas.	CO2	L3
11	Define polytropic efficiency of a compressor. What is reheat factor in a multistage turbine? Prove that R.F is greater than unity.	CO2	L3
12	Air enters a compressor at a static pressure of 1.5 bar, a static temperature of 15 °C and a flow velocity of 50 m/s. At the exit the static pressure is 3 bar, the static temperature is 100° C and the flow velocity is 100 m/s. The outlet is 1 m above the inlet. Evaluate: i) The isentropic change in enthalpy	CO2	L3

	ii) The actual change in enthalpy iii) Efficiency of compressor.		
13	In a reservoir model built to a scale of 1:200, the rate of flow through the sluice into the canal is 2lpm and it takes 28.6h to drain the reservoir. Predict the prototype discharge and the time for emptying the reservoir	CO2	L2
14	What is Reheat factor? Show that the reheat factor is greater than unity in multistage turbine	CO2	L2
15	Combustion products approaches an axial fliw turbine rotor with absolute velocity of 550m/s and a direction of 18^0 from the wheel tangent the mass flow rate is 60kg/s.If the absolute velocity at the rotor exit is axially directed.when the blade speed is 300m/s, find the power output & DOR	CO2	L3
16	Derive an expression for energy transfer and DOR for Axial flow pumps and compressors.	CO1	L2
17	The total power input at a stage in an axial flow compressor with symmetric inlet and outlet velocity triangles (R=0.5) is 27.85kj/kg of air flow .If the blade speed is 180m/s thought the rotor, draw the velocity triangles and compute the inlet and outlet rotor blade angles. Assume axial velocity component to be 120m/s would you recommend this type of compressor.	CO2	L3
18	Two geometrically similar pumps are running at the same speed of 1000rpm. One has an impeller dia of 3.0m and lifts water at the rate of 20lt/s against a head of 15m.Determine the head and impeller dia of other pump to deliver half the discharge	CO2	L3
19	Define specific speed for pump and turbine. Explains the significance of flow coefficient, Head coefficient and power coefficient.	CO2	
e	**Experiences**	-	-
1		CO1	L2
2			
3			
4		CO2	L2
5			

Module – 2

Title:	ENERGY EXCHANGE IN TURBO MACHINES	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Understanding the components of energy transfer and find energy transfer and dor using velocity triangles.	CO2	L2
2	Perform the preliminary design of turbo machines (pumps, rotary compressors and turbines)	CO2	L3
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	**-**	**-**
11	Energy exchange in Turbo machines: Euler's turbine equation, Alternate form of Euler's turbine equation,	CO3	L2
12	Velocity triangles for different values of degree of reaction,	CO3	L2
13	Components of energy transfer,	CO3	L2
14	Degree of Reaction, utilization factor,	CO3	L2
15	Relation between degree of reaction and Utilization factor,	CO3	L2
16	General Analysis of Turbo machines: Radial flow compressors and pumps – general analysis	CO4	L3

17	General Analysis of Turbo machines: Radial flow pumps ,	CO4	L2
18	Effect of blade discharge angle on energy transfer and degree of reaction, Theoretical head – capacity relationship,	CO4	L2
19	energy transfer and degree of reaction.	CO4	L2
20	problems	CO4	L3
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	In research and development organizations for predicting the parameters for analysis of actual turbines.	CO3	L2
2	In research and development organizations for predicting the parameters for analysis of actual fluid machines	CO4	L3
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
20	Derive an alternate form of Euler" s turbine equation and explain the significance of each energy components	CO3	L2
21	Draw the Velocity triangles for different values of degree of reaction,	CO3	L2
22	What is Degree of Reaction, utilization factor?	CO3	L2
23	Derive the Relation between degree of reaction and Utilization factor,	CO4	L2
24	Derive the expression for, energy transfer for axial flow compressor	CO4	L2
25	Derive the expression for, degree of reaction, for axial flow compressor	CO4	L2
26	Derive an expression of theoretical head capacity relationship of radial outward flow devices	CO3	L2
27	Explain the Theoretical head – capacity relationship	CO3	L2
28	An output of 10 KW was recorded on a turbine of 0.5 m dia running at a speed of 800 rpm under a head of 20 m. What is the diameter and output of another turbine which works under head of 180 m, at a speed of 200 rpm when their efficiencies are same? Find the specific speed and name the turbine which you preferred	CO4	L2
29	Radial outward flow turbo machine has no inlet whirl. The blade speed at exit is twice that at the inlet. The radial velocity remains constant. Inlet blade angle is 45°. Show that the degree of reaction for this machine is given by, R=(2 + cot 13 2)/4	CO3	L2
30	Air enters a compressor at a static pressure of 1.5 bar, a static temperature of 15 °C and aflow velocity of 50 m/s. At the exit the static pressure is 3 bar, the static temperature is100° C and the flow velocity is 100 m/s. The outlet is 1 m above the inlet. Evaluate: i) The isentropic change in enthalpy ii) The actual change in enthalpy iii) Efficiency of compressor.	CO3	L2
e	**Experiences**	-	-
1		CO3	L2
2			

E1. CIA EXAM – 1

a. Model Question Paper - 1

Crs Code:	17ME53	Sem:	V	Marks:	30	Time:	75 minutes	
Course:	TURBO MACHINES							

-	-	**Note: Answer all questions, each carry equal marks. Module : 1, 2**	**Marks**	**CO**	**Level**
1	a	Define Turbo machines.	2	CO1	L1
	b	With neat sketch explain the parts of a Turbo machines.	4	CO1	L2
	c	What are the classification of Turbo machines?	3	CO2	L3
	d	Two geometrically similar pumps are running at the same speed of 1000 rpm. One pump hasan impeller diameter of 0.3 m and lifts water at rate of 20 es against a head of 15 m. Determine the head and impeller diameter of other pump to deliver half the discharge	6	CO2	L3
		OR			
2	a	Define the following for a compression process : (i) Total to total efficiency (ii) Static to static efficiency	5	CO2	L3
	b	What is Reheat factor? Show that the reheat factor is greater than unity in multistage turbine	5	CO2	L3

	c	Explain static and stagnation state for a fluid. Obtain an expression relating static and stagnation temperature for a perfect gas.	5	CO2	L3
3	a	Derive an alternate form of Euler" s turbine equation and explain the significance of each energy components	5	CO3	L2
	b	Draw the Velocity triangles for different values of degree of reaction,	4	CO4	L3
	d	An output of 10 KW was recorded on a turbine of 0.5 m dia running at a speed of 800 rpm under a head of 20 m. What is the diameter and output of another turbine which works under head of 180 m, at a speed of 200 rpm when their efficiencies are same? Find the specific speed and name the turbine which you preferred	6	CO3	L3
		OR			
4	a	Derive an energy transfer for axial flow compressor.	5	CO4	L2
	b	Why the discharge blade angle has considerable effect in the analysis of a turbo machine?	4	CO3	L2
	c	A hydraulic reaction turbine of the radial inward flow type, works under a head of 160 m of water. At the point of fluid entry, the rotor blade angle is 119 ° and the diameter of the runner 3.65 m. At the exit, the runner diameter is 2.45m. If the absolute velocity at the wheel outlet is radially directed with a magnitude of 15.5 m/s and the radial component of velocity at the inlet is 10.3 m/s. Determine : i) the power developed by the machine, for a flow rate of 110 m3/s ; ii) the degree of reaction and iii) the utilization factor.	6	CO4	L3

b. Assignment -1

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

Model Assignment Questions							
Crs Code:	17ME53	Sem:	IV	Marks:	10	Time:	90 – 120 minutes
Course:	TURBO MACHINES				Module : 1, 2		
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1		Define Turbo machines.	10	CO1	L2
2		With neat sketch explain the parts of a Turbo machines.	10	CO1	L2
3		What are the classification of Turbo machines?	10	CO1	L2
4		Wat are the differences between positive displacement machines and turbo machines?	10	CO1	L2
5		Explain the effect of Reynold number on the performance analysis of turbo machines..	10	CO1	L2
6		Explain the significance of flow coefficient, head coefficient and power coefficient with equations.	10	CO2	L2
7		Two geometrically similar pumps are running at the same speed of 1000 rpm. One pump hasan impeller diameter of 0.3 m and lifts water at rate of 20 es against a head of 15 m.Determine the head and impeller diameter of other pump to deliver half the discharge.	10	CO1	L2
8		Define the following for a compression process : (i) Total to total efficiency (ii) Static to static efficiency	10	CO1	L2
9		What is Reheat factor? Show that the reheat factor is greater than unity in multistage turbine	10	CO1	L2
10		Explain static and stagnation state for a fluid. Obtain an expression relating static and stagnation temperature for a perfect gas.	10	CO1	L2
11		Define polytropic efficiency of a compressor. What is reheat factor in a multistage turbine? Prove that R.F is greater than unity.	10	CO1	L2
12		Air enters a compressor at a static pressure of 1.5 bar, a static temperature of 15 °C and a flow velocity of 50 m/s. At the exit the static pressure is 3 bar, the static temperature is 100° C and the flow velocity is 100 m/s. The outlet is 1 m above the inlet. Evaluate: i) The isentropic change in enthalpy ii) The actual change in enthalpy iii) Efficiency of compressor.	10	CO1	L2
13		In a reservoir model built to a scale of 1:200, the rate of flow through the sluice into the canal is 2lpm and it takes 28.6h to drain the reservoir. Predict the prototype discharge and the time for emptying the reservoir	10	CO1	L2

14		What is Reheat factor? Show that the reheat factor is greater than unity in multistage turbine	10	CO1	L2
15		Combustion products approaches an axial fliw turbine rotor with absolute velocity of 550m/s and a direction of 18^0 from the wheel tangent the mass flow rate is 60kg/s.If the absolute velocity at the rotor exit is axially directed.when the blade speed is 300m/s, find the power output & DOR	10	CO1	L2
16		Derive an expression for energy transfer and DOR for Axial flow pumps and compressors.	10	CO2	L2
17		The total power input at a stage in an axial flow compressor with symmetric inlet and outlet velocity triangles (R=0.5) is 27.85kj/kg of air flow .If the blade speed is 180m/s thought the rotor, draw the velocity triangles and compute the inlet and outlet rotor blade angles. Assume axial velocity component to be 120m/s would you recommend this type of compressor.	10	CO2	L2
18		Two geometrically similar pumps are running at the same speed of 1000rpm. One has an impeller dia of 3.0m and lifts water at the rate of 20lt/s against a head of 15m.Determine the head and impeller dia of other pump to deliver half the discharge	10	CO1	L2
19		Define specific speed for pump and turbine. Explains the significance of flow coefficient, Head coefficient and power coefficient.	10	CO1	L2
20		Derive an alternate form of Euler" s turbine equation and explain the significance of each energy components	10	CO1	L2
21		Draw the Velocity triangles for different values of degree of reaction,	10	CO1	L2
22		What is Degree of Reaction, utilization factor?	10	CO2	L2
23		Derive the Relation between degree of reaction and Utilization factor,	10	CO2	L2
24		Derive the expression for, energy transfer for axial flow compressor	10	CO1	L2
25		Derive the expression for, degree of reaction, for axial flow compressor	10	CO3	L2
26		Derive an expression of theoretical head capacity relationship of radial outward flow devices	10	CO3	L2
27		Explain the Theoretical head – capacity relationship	10	CO3	L2
28		An output of 10 KW was recorded on a turbine of 0.5 m dia running at a speed of 800 rpm under a head of 20 m. What is the diameter and output of another turbine which works under head of 180 m, at a speed of 200 rpm when their efficiencies are same? Find the specific speed and name the turbine which you preferred	10	CO4	L2
29		Radial outward flow turbo machine has no inlet whirl. The blade speed at exit is twice that at the inlet. The radial velocity remains constant. Inlet blade angle is 45°. Show that the degree of reaction for this machine is given by, R=(2 + cot 13 2)/4	10	CO4	L2
30		Air enters a compressor at a static pressure of 1.5 bar, a static temperature of 15 °C and aflow velocity of 50 m/s. At the exit the static pressure is 3 bar, the static temperature is100° C and the flow velocity is 100 m/s. The outlet is 1 m above the inlet. Evaluate: i) The isentropic change in enthalpy ii) The actual change in enthalpy iii) Efficiency of compressor.	10	CO4	L2
31		Define Turbo machines.	10	CO3	L2
32		With neat sketch explain the parts of a Turbo machines.	10	CO3	L2
33		What are the classification of Turbo machines?	10	CO4	L2
34		Two geometrically similar pumps are running at the same speed of 1000 rpm. One pump hasan impeller diameter of 0.3 m and lifts water at rate of 20 es against a head of 15 m. Determine the head and impeller	10	CO3	L2

		diameter of other pump to deliver half the discharge			
35		Draw the Velocity triangles for different values of degree of reaction,	10	CO3	L2
36		An output of 10 KW was recorded on a turbine of 0.5 m dia running at a speed of 800 rpm under a head of 20 m. What is the diameter and output of another turbine which works under head of 180 m, at a speed of 200 rpm when their efficiencies are same? Find the specific speed and name the turbine which you preferred	10	CO3	L2

D2. TEACHING PLAN - 2

Module – 3

Title:	STEAM TURBINE	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Students should be able to Understanding work done, efficiency of the single and multistage steam impulse type turbine and find these using velocity triangles graphical method.	CO5	L2
2	Students should be able to Understanding work done, efficiency of the single and multistage steam reaction turbine and find these using velocity triangles graphical method.	CO6	L2
b	***Course Schedule***		
Class No	**Portion covered per hour**	**-**	**-**
21	Steam Turbine: working principle,classification	CO3	L2
22	Single stage impulse turbine, Need and methods of compounding,	CO3	L3
23	condition for maximum blade efficiency	CO3	L3
24	stage efficiency, Multi-stage impulse turbine, expression for maximum utilization factor	CO3	L3
25	problems	CO4	L3
26	Reaction turbine	CO4	L3
27	Parsons’s turbine	CO4	L3
28	condition for maximum utilization factor	CO4	L3
29	Reaction staging	CO4	L3
30	Problems.	CO4	L3
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	Power generation in steam power plant	CO5	L3
2	Power generation in steam power plant	CO6	L3
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
37	Why is compounding of steam turbine necessary?	CO5	L2
38	Describe the velocity compounding of steam turbines.	CO6	L2
39	Explain briefly a two stage pressure compounded impulse turbine and show the pressure and velocity variations across the turbine.	CO5	L2
40	Prove that the maximum rotor efficiency with equiangular rotor blades for impulse turbines	CO6	L3
41	What is meant by reaction staging? Derive the maximum stage efficiency of Parson's reaction turbine.	CO5	L3
42	Difference between impulse type and reaction type	CO6	L2
43	single stage impulse turbine rotor has a diameter of 1.2m running at 3000 rpm. The nozzle angle is 18° . Blade speed ratio is 0.42. The ratio of relative velocity at outlet to relative velocity at inlet is 0.9. The outlet angle of the blade is 3 ° smaller than the inlet angle. The steam flow rate is 5kg/s. Draw the velocity diagram and find the following : i) Velocity of whirl ii) Axial thrust on the bearings iii) Blade angles iv) Power developed.	CO5	L3
44	Draw the inlet and exit velocity triangles for a single stage steam turbine.	CO6	L3

	Derive for maximum blade efficiency		
45	Define and explain i) nozzle efficiency ii) diagram efficiency iii) stage efficiency iv) compounding of steam turbines.	CO5	L2
46	In a curtis stage turbine, steam enters the first row of moving blades at 700m/s. The outletangles of the nozzle, the first rotor blade, the stator blade and the last rotor blade37°. The mean blade speed is 160m/sec, the bladerespectively are 17°, 23°,coefficient is 0.93 for all blades and steam flow rate is 162 kg/min. Estimate i) power developed in the stage ii) rotor efficiency iii) axial thrust and iv) tangential force on blades	CO6	L3
e	**Experiences**	-	-
1		CO6	L2
2			
3			
4		CO6	L2
5			

Module – 4

Title:	HYDRAULIC TURBINES	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Students should be able to understanding the working principles Pelton turbine and determine the Design parameters using velocity triangles analytical method.	CO7	L3
2	Students should be able to Understanding the working principles of Francis turbine, Kaplan turbine and determine the Design parameters of these using velocity triangles by analytical method.	CO8	L3
b	***Course Schedule***		
Class No	**Portion covered per hour**	-	-
31	Hydraulic Turbines: Classification,	CO7	L2
32	various efficiencies.	CO7	L2
33	Pelton turbine – velocity triangles,	CO7	L3
34	design parameters, Maximum efficiency.	CO7	L3
35	Problems.	CO7	L3
36	Francis turbine - velocity triangles, design parameters,	CO8	L3
37	runner shapes for different blade speeds.	CO8	L3
38	Draft tubes- Types and functions.	CO8	L2
39	Kaplan and Propeller turbines - velocity triangles, design parameters.	CO8	L3
40	Problems.	CO8	L3
c	**Application Areas**	-	-
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	Power generation in Hydroelectric power plant	CO7	L3
2	Power generation in Hydroelectric power plant	CO8	L3
d	**Review Questions**	-	-
-			
47	What is Hydraulic Turbines and explain the classification,	CO7	L1
48	Explain the various efficiencies.	CO7	L2
49	Derive the expression for work done for pelton wheel	CO8	L3
50	Derive the expression for condition for Maximum efficiency of pelton wheel	CO7	L3
51	Show that for maximum utilization, the speed of the wheel is equal to half the speed of jet.	CO8	L3
52	Derive the expression for work done for Francis turbine	CO8	L3
53	Explain the runner shapes for different blade speeds.	CO8	L2
54	What is Draft tube and Explain the types and functions.	CO8	L2
55	Kaplan and Propeller turbines - velocity triangles, design parameters.	CO8	L3
57	A Kaplan turbine develops 9000 kW under a head of 10m. Overall efficiency of the turbineis 85%. The speed ratio based on outer diameter is 2.2 and flow ratio 0.66. Diameter of theboss is 0.4 times the outer diameter of the runner. Determine the diameter of the runner,boss diameter and specific speed of the runner.	CO8	L3

e	**Experiences**	-	-
1		CO7	L2
2			
3			
4		CO8	L2
5			

E2. CIA EXAM – 2

a. Model Question Paper - 2

Crs Code:	17ME53	Sem:	V	Marks:	30	Time:	75 minutes
Course:	TURBO MACHINES						

-	-	**Note: Answer all questions, each carry equal marks. Module : 3, 4**	**Marks**	**CO**	**Level**
1	a	Explain briefly a two stage pressure compounded impulse turbine and show the pressure and velocity variations across the turbine.	7	CO7	L1
	b	Prove that the maximum rotor efficiency with equiangular rotor blades for impulse turbines	8	CO8	L2
		OR			
2	a	Define and explain i) nozzle efficiency ii) diagram efficiency iii) stage efficiency iv) compounding of steam turbines.	7	CO7	L3
	b	In a Curtis stage turbine, steam enters the first row of moving blades at700m/s. The outlet angles of the nozzle, the first rotor blade, the stator blade and the last rotor blade37°. The mean blade speed is 160m/sec, the blade respectively are 17°, 23°,coefficient is 0.93 for all blades and steam flow rate is 162 kg/min. Estimate i) power developed in the stage ii) rotor efficiency iii) axial thrust and iv) tangential force on blades	8	CO8	L3
3	a	Derive the expression for work done for pelton wheel	7	CO8	L3
	d	A Kaplan turbine develops 9000 kW under a head of 10m. Overall efficiency of the turbineis 85%. The speed ratio based on outer diameter is 2.2 and flow ratio 0.66. Diameter of theboss is 0.4 times the outer diameter of the runner. Determine the diameter of the runner,boss diameter and specific speed of the runner.	8	CO8	L3
		OR			
4	a	Derive the expression for condition for Maximum efficiency of pelton wheel	7	CO7	L3
	b	Show that for maximum utilization, the speed of the wheel is equal to half the speed of jet.	8	CO8	L3

b. Assignment – 2

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

Model Assignment Questions							
Crs Code:	17ME53	Sem:	V	Marks:	10	Time:	90 – 120 minutes
Course:	TURBO MACHINES				Module : 3, 4		
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	**USN**	**Assignment Description**	**Marks**	**CO**	**Level**
1		Why is compounding of steam turbine necessary?	10	CO5	L2
2		Describe the velocity compounding of steam turbines.	10	CO6	L2
3		Explain briefly a two stage pressure compounded impulse turbine and show the pressure and velocity variations across the turbine.	10	CO5	L2
4		Prove that the maximum rotor efficiency with equiangular rotor blades for impulse turbines	10	CO6	L3
5		What is meant by reaction staging? Derive the maximum stage efficiency of Parson's reaction turbine.	10	CO5	L3

6		Difference between impulse type and reaction type	10	CO6	L2
7		single stage impulse turbine rotor has a diameter of 1.2m running at 3000 rpm. The nozzle angle is 18° . Blade speed ratio is 0.42. The ratio of relative velocity at outlet to relative velocity at inlet is 0.9. The outlet angle of the blade is 3 ° smaller than the inlet angle. The steam flow rate is 5kg/s. Draw the velocity diagram and find the following : i) Velocity of whirl ii) Axial thrust on the bearings iii) Blade angles iv) Power developed.	10	CO5	L3
8		Draw the inlet and exit velocity triangles for a single stage steam turbine. Derive for maximum blade efficiency	10	CO6	L3
9		define and explain i) nozzle efficiency ii) diagram efficiency iii) stage efficiency iv) compounding of steam turbines.	10	CO5	L2
10		In a curtis stage turbine, steam enters the first row of moving blades at 700m/s. The outletangles of the nozzle, the first rotor blade, the stator blade and the last rotor blade37°. The mean blade speed is 160m/sec, the bladerespectively are 17°, 23°,coefficient is 0.93 for all blades and steam flow rate is 162 kg/min. Estimate i) power developed in the stage ii) rotor efficiency iii) axial thrust and iv) tangential force on blades	10	CO6	L3
11		What is Hydraulic Turbines and explain the classification,	10	CO7	L1
12		Explain the various efficiencies.	10	CO7	L2
13		Derive the expression for work done for pelton wheel	10	CO8	L3
14		Derive the expression for condition for Maximum efficiency of pelton wheel	10	CO7	L3
15		Show that for maximum utilization, the speed of the wheel is equal to half the speed of jet.	10	CO8	L3
16		Derive the expression for work done for Francis turbine	10	CO8	L3
17		Explain the runner shapes for different blade speeds.	10	CO8	L2
18		What is Draft tube and Explain the types and functions.	10	CO8	L2
19		Kaplan and Propeller turbines - velocity triangles, design parameters.	10	CO8	L3
20		A Kaplan turbine develops 9000 kW under a head of 10m. Overall efficiency of the turbineis 85%. The speed ratio based on outer diameter is 2.2 and flow ratio 0.66. Diameter of theboss is 0.4 times the outer diameter of the runner. Determine the diameter of the runner,boss diameter and specific speed of the runner.	10	CO8	L3
21		Explain briefly a two stage pressure compounded impulse turbine and show the pressure and velocity variations across the turbine.	10	CO5	L2
22		Prove that the maximum rotor efficiency with equiangular rotor blades for impulse turbines	10	CO6	L3
23		Define and explain i) nozzle efficiency ii) diagram efficiency iii) stage efficiency iv) compounding of steam turbines.	10	CO5	L2
24		In a Curtis stage turbine, steam enters the first row of moving blades at700m/s. The outlet angles of the nozzle, the first rotor blade, the stator blade and the last rotor blade37°. The mean blade speed is 160m/sec, the blade respectively are 17°, 23°,coefficient is 0.93 for all blades and steam flow rate is 162 kg/min. Estimate i) power developed in the stage ii) rotor efficiency iii) axial thrust and iv) tangential force on blades	10	CO6	L3
25		Derive the expression for work done for pelton wheel	10	CO5	L3
26		A Kaplan turbine develops 9000 kW under a head of 10m. Overall efficiency of the turbineis 85%. The speed ratio based on outer diameter is 2.2 and flow ratio 0.66. Diameter of theboss is 0.4 times the outer diameter of the runner. Determine the diameter of the runner,boss diameter and specific speed of the runner.	10	CO6	L3
27		Derive the expression for condition for Maximum efficiency of pelton wheel	10	CO5	L3
28		Show that for maximum utilization, the speed of the wheel is equal to half the speed of jet.	10	CO6	L3
29		Derive the expression for work done for Francis turbine	10	CO8	L3

30		Explain the runner shapes for different blade speeds.	10	CO8	L2
31		What is Draft tube and Explain the types and functions.	10	CO8	L2
32		Kaplan and Propeller turbines - velocity triangles, design parameters.	10	CO8	L3
33		Prove that the maximum rotor efficiency with equiangular rotor blades for impulse turbines	10	CO6	L3
34		Define and explain i) nozzle efficiency ii) diagram efficiency iii) stage efficiency iv) compounding of steam turbines.	10	CO5	L2
35		Derive the expression for work done for pelton wheel	10	CO8	L3
36		Derive the expression for condition for Maximum efficiency of pelton wheel	10	CO7	L3

D3. TEACHING PLAN - 3

Module – 5

Title:	CENTRIFUGAL PUMPS AND COMPRESSORS	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Students should be able to explains the working and efficiencies of Centrifugal and axial pump find these by analytical method..	CO9	L2
2	Students should be able to explains the working and efficiencies of Centrifugal and axial compressors and find these by analytical method..	CO10	L2
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	**-**	**-**
41	Centrifugal Pumps: Classification and parts of centrifugal pump,	CO9	L3
42	different heads and efficiencies of centrifugal pump,	CO9	L3
43	Minimum speed for starting the flow, Maximum suction lift, Net positive suctio	CO9	L3
44	Cavitation, Need for priming, Pumps in series and parallel.	CO9	L3
45	Problems.	CO9	L3
46	Centrifugal Compressors: Stage velocity triangles, slip factor, power input factor	CO10	L3
47	Stage work, Pressure developed, stage efficiency and surging	CO10	L3
48	Axial flow Compressors: Expression for pressure ratio developed in a stage,	CO10	L3
49	work done factor, efficiencies and stalling. Problems.	CO10	L3
50	Problems.	CO10	L3
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	Water well pumps and inclined mounted pumps.	CO9	L3
2	Refrigeration and air conditioning technology.	CO10	L3
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
58	Define Centrifugal Pumps: and explain Classification of Centrifugal Pumps	CO9	L3
59	With neat sketch explain parts of centrifugal pump,	CO9	L3
60	What are the different heads and efficiencies of centrifugal pump,	CO9	L3
61	Minimum speed for starting theflow, Maximum suction lift, Net positive suction head	CO9	L3
62	Explain the Cavitation, Need for priming, Pumps in series and parallel.	CO9	L3
63	A three stage centrifugal pump has impeller 40 cm in decimeter and '2.5 cm wide at outlet.The vanes are cuived back at an angle of 30° and reduces the circumferential area by 15%. The manometric efficiency = 85% and overall efficiency = 75%. Determine the headgenerated by the pump when running at 1200 rpm and discharges 0.06 m3/sec. Find the shaftpower also.	CO9	L3
64	Define Stage velocity triangles, slip factor, power input facto	CO10	L3
65	Explain the Stage work, stage efficiency and surging with respect to compressor.	CO10	L3

66	Expression for pressure ratio developed in a stage for Axial flow Compressors:	CO10	L3
67	Define work done factor, efficiencies and stalling.	CO10	L3
68	An axial flow compressor has the following data entry condition 1 bar, 20 reaction 50% mean blade ring diameter 36 cm, Rotational speed 18000rpm blade height at entry 6 cm, Blade angle at rotor and stator exit 65' axial velocity 180 m/s mechanical efficiency 0.967.Find (i) Guide blade angle at outlet. (ii) Power required to drive the compressor.	CO10	L3
69	Minimum speed for starting the flow, Maximum suction lift, Net positive suction head	CO9	L2
70	Explain the Cavitation, Need for priming, Pumps in series and parallel.	CO9	L2
71	Define work done factor, efficiencies and stalling.	CO9	L2
e	**Experiences**	-	-
1		CO10	L2
2		CO9	

E3. CIA EXAM – 3

a. Model Question Paper - 3

Crs Code:	17ME53	Sem:	V	Marks:	30	Time:	75 minutes
Course:	TURBO MACHINES						

-	-	Note: Answer all questions, each carry equal marks. Module : 5	Marks	CO	Level
1	a	Minimum speed for starting the flow, Maximum suction lift, Net positive suction head	5	CO9	L3
	b	Explain the Cavitation, Need for priming, Pumps in series and parallel.	5	CO9	L3
	c	Define work done factor, efficiencies and stalling.	5	CO9	L3
2	a	Minimum speed for starting theflow, Maximum suction lift, Net positive suction head	7	CO9	L3
	b	A three stage centrifugal pump has impeller 40 cm in decimeter and '2.5 cm wide at outlet.The vanes are cuived back at an angle of 30° and reduces the circumferential area by 15%. The manometric efficiency = 85% and overall efficiency = 75%. Determine the headgenerated by the pump when running at 1200 rpm and discharges 0.06 m3/sec. Find the shaftpower also.	8	CO9	L3
3	a	Explain the Stage velocity triangles, slip factor, power input facto centrifugal compressor	7	CO10	L3
	b	Derive an expression for pressure ratio developed in a stage for Axial flow Compressors:	8	CO10	L3
4	a	Explain the Stage velocity triangles, slip factor, power input facto Axial flow Compressors:	7	CO10	L3
	b	An axial flow compressor has the following data entry condition 1 bar, 20 reaction 50% mean blade ring diameter 36 cm, Rotational speed 18000rpm blade height at entry 6 cm, Blade angle at rotor and stator exit 65' axial velocity 180 m/s mechanical efficiency 0.967.Find (i) Guide blade angle at outlet. (ii) Power required to drive the compressor.	8	CO10	L3

b. Assignment – 3

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

Model Assignment Questions							
Crs Code:	17ME53	Sem:	V	Marks:	10	Time:	90 – 120 minutes
Course:	TURBO MACHINES				Module : 5		
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1		Explain the Classification and parts of centrifugal pump,	10	CO9	L2
2		different heads and efficiencies of centrifugal pump,	10	CO10	L2
3		Minimum speed for starting the flow, Maximum suction lift, Net positive suctio	10	CO9	L2
4		Cavitation, Need for priming, Pumps in series and parallel.	10	CO9	L2
5		An axial flow compressor has the following data entry condition 1 bar, 20 reaction 70% mean blade ring diameter 36 cm, Rotational speed 10000rpm blade height at entry 6 cm, Blade angle at rotor and stator exit 65' axial velocity 180 m/s mechanical efficiency 0.867.Find (i) Guide blade angle at outlet. (ii) Power required to drive the compressor.	10	CO9	L3
6		Centrifugal Compressors: Stage velocity triangles, slip factor, power input factor	10	CO10	L2
7		Stage work, Pressure developed, stage efficiency and surging	10	CO10	L2
8		Derive an expression for pressure ratio developed in a stage,	10	CO9	L2
9		work done factor, efficiencies and stalling. Problems.	10	CO10	L2
10		A three stage centrifugal pump has impeller 40 cm in decimeter and '2.5 cm wide at outlet.The vanes are cuived back at an angle of 30° and reduces the circumferential area by 15%. The manometric efficiency = 85% and overall efficiency = 75%. Determine the headgenerated by the pump when running at 1200 rpm and discharges 0.06 m3/sec. Find the shaftpower also.	10	CO9	L3
11		Define Stage velocity triangles, slip factor, power input facto	10	CO10	L2
12		Explain the Stage work, stage efficiency and surging with respect to compressor.	10	CO9	L3
13		Expression for pressure ratio developed in a stage for Axial flow Compressors:	10	CO9	L3
14		Define work done factor, efficiencies and stalling.	10	CO9	L2
15		An axial flow compressor has the following data entry condition 1 bar, 20 reaction 50% mean blade ring diameter 36 cm, Rotational speed 18000rpm blade height at entry 6 cm, Blade angle at rotor and stator exit 65' axial velocity 180 m/s mechanical efficiency 0.967.Find (i) Guide blade angle at outlet. (ii) Power required to drive the compressor.	10	CO10	L3
16		Minimum speed for starting the flow, Maximum suction lift, Net positive suction head	10	CO9	L2
17		Explain the Cavitation, Need for priming, Pumps in series and parallel.	10	CO9	L2
18		Define work done factor, efficiencies and stalling.	10	CO9	L2
19		Minimum speed for starting the flow, Maximum suction lift, Net positive suction head	10	CO10	L2
20		Explain the Cavitation, Need for priming, Pumps in series and parallel.	10	CO10	L2
21		Define work done factor, efficiencies and stalling.	10	CO10	L2
22		Minimum speed for starting theflow, Maximum suction lift, Net positive suction head	10	CO10	L2
23		A three stage centrifugal pump has impeller 40 cm in decimeter and '2.5 cm wide at outlet.The vanes are cuived back at an angle of 30° and reduces the circumferential area by 15%. The manometric efficiency = 85% and overall efficiency = 75%. Determine the headgenerated by the pump when running at 1200 rpm and discharges 0.06 m3/sec. Find the shaftpower also.	10	CO9	L3
24		Explain the Stage velocity triangles, slip factor, power input facto centrifugal compressor	10	CO10	L2

25		Derive an expression for pressure ratio developed in a stage for Axial flow Compressors:	10	CO9	L2
26		Explain the Stage velocity triangles, slip factor, power input facto Axial flow Compressors:	10	CO9	L2
27		An axial flow compressor has the following data entry condition 1 bar, 20 reaction 70% mean blade ring diameter 36 cm, Rotational speed 10000rpm blade height at entry 6 cm, Blade angle at rotor and stator exit 65' axial velocity 180 m/s mechanical efficiency 0.867.Find (i) Guide blade angle at outlet. (ii) Power required to drive the compressor.	10	CO9	L3
28		Explain the Classification and parts of centrifugal pump,	10	CO10	L2
29		different heads and efficiencies of centrifugal pump,	10	CO10	L2
30		Minimum speed for starting the flow, Maximum suction lift, Net positive suctio	10	CO9	L2
31		Cavitation, Need for priming, Pumps in series and parallel.	10	CO10	L2
32		Problems.	10	CO9	L2
33		Centrifugal Compressors: Stage velocity triangles, slip factor, power input factor	10	CO10	L2
34		Stage work, Pressure developed, stage efficiency and surging	10	CO9	L2
35		Axial flow Compressors: Expression for pressure ratio developed in a stage,	10	CO9	L2
36		Explain work done factor, efficiencies and stalling. Problems.	10	CO9	L2

F. EXAM PREPARATION

1. University Model Question Paper

Course:	TURBO MACHINES					Month / Year		01/01/20
Crs Code:	17ME53	Sem:	V	Marks:	100	Time:		180 minutes

Module	Note	Answer all FIVE full questions. All questions carry equal marks.	Marks	CO	
1	a	Define Turbo machines. With neat sketch explain the parts of a Turbo machines.	6	CO1	
	b	What are the classification of Turbo machines?	4	CO2	
	c	Explain the significance of flow coefficient, head coefficient and power coefficient with equations.	6	CO2	
		OR			
	a	Define the following for a compression process : (i) Total to total efficiency (ii) Static to static efficiency	4	CO2	
	b	What is Reheat factor? Show that the reheat factor is greater than unity in multistage turbine	6	CO2	
	c	Explain static and stagnation state for a fluid. Obtain an expression relating static and stagnation temperature for a perfect gas.	6	CO2	
2	a	Derive an alternate form of Euler" s turbine equation and explain the significance of each energy components	8	CO3	
	b	An output of 10 KW was recorded on a turbine of 0.5 m dia running at a speed of 800 rpm under a head of 20 m. What is the diameter and output of another turbine which works under head of 180 m, at a speed of 200 rpm when their efficiencies are same? Find the specific speed and name the turbine which you preferred	8	CO3	
		OR			
	a	Derive the expression for, degree of reaction, for axial flow compressor	4	CO4	
	b	Derive an expression of theoretical head capacity relationship of radial outward flow devices	6	CO4	
	c	Air enters a compressor at a static pressure of 1.5 bar, a static temperature of 15 °C and aflow velocity of 50 m/s. At the exit the static pressure is 3 bar, the static temperature is100° C and the flow velocity is 100 m/s. The outlet is 1 m above the inlet. Evaluate: i) The isentropic change in enthalpy ii) The actual change in enthalpy	6	CO4	

		iii) Efficiency of compressor.			
3	a	Draw the inlet and exit velocity triangles for a single stage steam turbine. Derive for maximum blade efficiency	8	CO5	
	b	single stage impulse turbine rotor has a diameter of 1.2m running at 3000 rpm. The nozzle angle is 18° . Blade speed ratio is 0.42. The ratio of relative velocity at outlet to relative velocity at inlet is 0.9. The outlet angle of the blade is 3 ° smaller than the inlet angle. The steam flow rate is 5kg/s. Draw the velocity diagram and find the following : i) Velocity of whirl ii) Axial thrust on the bearings iii) Blade angles iv) Power developed.	8	CO5	
		OR			
	a	Define and explain i) nozzle efficiency ii) diagram efficiency iii) stage efficiency iv) compounding of steam turbines.	8	CO6	
	b	In a Curtis stage turbine, steam enters the first row of moving blades at 700m/s. The outlet angles of the nozzle, the first rotor blade, the stator blade and the last rotor blade37°. The mean blade speed is 160m/sec, the blade respectively are 17°, 23°,coefficient is 0.93 for all blades and steam flow rate is 162 kg/min. Estimate i) power developed in the stage ii) rotor efficiency iii) axial thrust and iv) tangential force on blades	8	CO6	
4	a	Derive the expression for condition for Maximum efficiency of pelton wheel	8	CO7	
	b	Show that for maximum utilization, the speed of the wheel is equal to half the speed of jet.	8	CO7	
		OR			
	a	What is Draft tube and Explain the types and functions.	6	CO8	
	b	Explain hydraulic efficiency,overall efficiency, volumetric efficiency, with respect to hydraulic machines	4	CO8	
	c	A Kaplan turbine develops 9000 kW under a head of 10m. Overall efficiency of the turbineis 85%. The speed ratio based on outer diameter is 2.2 and flow ratio 0.66. Diameter of theboss is 0.4 times the outer diameter of the runner. Determine the diameter of the runner,boss diameter and specific speed of the runner.	6		
5	a	Minimum speed for starting the flow, Maximum suction lift, Net positive suction head	8	CO9	
	b	A three stage centrifugal pump has impeller 40 cm in decimeter and '2.5 cm wide at outlet.The vanes are cuived back at an angle of 30° and reduces the circumferential area by 15%. The manometric efficiency = 85% and overall efficiency = 75%. Determine the headgenerated by the pump when running at 1200 rpm and discharges 0.06 m3/sec. Find the shaftpower also.	8	CO9	
		OR			
	a	Explain the Stage velocity triangles, slip factor, power input facto Axial flow Compressors:	8	CO10	
	b	An axial flow compressor has the following data entry condition 1 bar, 20 reaction 50% mean blade ring diameter 36 cm, Rotational speed 18000rpm blade height at entry 6 cm, Blade angle at rotor and stator exit 65' axial velocity 180 m/s mechanical efficiency 0.967.Find (i) Guide blade angle at outlet. (ii) Power required to drive the compressor.	8	CO10	

2. SEE Important Questions

Course:	TURBO MACHINES					Month / Year		01/01/19	
Crs Code:	17ME53	Sem: V	3	Marks:	80	Time:		180 minutes	
	Note	Answer all FIVE full questions.					-	-	
Modu	Q no.	Important Question					**Marks**	**CO**	**Year**

le					
1	1	Differentiate between a positive displacement machine and a turbomachine.	5	CO1	2016
	2	Define specific speed of a turbine. Derive an expression for specific speed of a pump.	5	CO2	2015
	3	An output of 10 KW was recorded on a turbine of 0.5 m dia running at a speed of 800 rpmunder a head of 20 m. What is the diameter and output of another turbine which works undera head of 180 m, at a speed of 200rpm when their efficiencies are same? Find the specific speed and name the turbine which you preferred	6	CO2	2017
2	1	Define degree of reaction (R). Derive an expression relating utilization factor with degree of reaction	8	CO3	2017
	2	Show that for an axial flow turbine subjected under maximum utilization factor condition,the speed ratio 4) is given by 2/3 cos a i , where `U' is the tangential speed of the rotor and`VI ' is the tangential jet velocity of the fluid. Assume flow velocity to remain constant Take Degree of Reaction R = 1/4.	8	CO4	2016
3	1	Define and explain diagram efficiency and stage efficiency.	6	CO5	2018
	2	velocity compounded impulse wheel has two rows of moving blades with a meandianieter of 70 cm. The speed of rotation is 3000 rpm and the nozzle angle is 16° and theestim,ated\ steam velocity at the nozzle outlet is 610 m/sec. The mass of steam passingthrough the blades per second is 5.5 kg. Assuming that the energy loss in each row of blades(moving and fixed) is 24% of the kinetic energy of the steam entering the blades. The outletangles of the blades are 1. First row of moving blades = 18° 2. Intermediate guide blades = 22° 3. Second row of moving blades = 38° Draw the diagram of relative velocities and derive the following: i) Blade inlet angles ii) Power developed in each row of moving blades (12 Marks) iii) Efficiency of the wheel ac a whole.	10	CO6	2018
4	1	with a neat sketch, explain the working of a Kaplan turbine. Draw the velocity triangles at inlet and outlet of the turbine. Also explain the function of draft tube.	8	CO7	2018
	2	An inward flow reaction turbine with radial discharge having overall efficiency 80% whenpower developed is 147 kW. The head is 8m. The peripheral velocity of the fluid is0.96 jiff and flow velocity of the fluid is 0.36 2gH . The speed of the rotor is 1500 rpmand hydraulic energy losses is 22% of available energy. Determine the following :i) Inlet guide vane and blade angles 2) width of the rotor 3) dia of rotor	8	CO8	2016
5	1	Explain the phenomenon of (i) surging (ii) chocking in the centrifugal compressor	8	CO9	2018
	2	A three stage centrifugal pump has impeller 40 cm in decimeter and '2.5 cm wide at outlet.The vanes are cuived back at an angle of 30° and reduces the circumferential area by 15%.The manometric efficiency = 85% and overall efficiency = 75%. Determine the headgenerated by the pump when running at 1200 rpm and discharges 0.06 m3/sec. Find the shaft power also.	8	CO10	2007

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:** Definition of turbo machine, parts of turbo machines, Comparison with positive	7	- L1 - L2	L2	Understand	- Lecture -	- Assignment -

	displacement machines, Classification, Dimensionless parameters and their significance, Effect of Reynolds number, Unit and specific quantities, model studies. (Note: Since dimensional analysis is covered in Fluid Mechanics subject, questions on dimensional analysis may not be given. However, dimensional parameters and model studies may be given more weightage.)					-	-
1	**Thermodynamics of fluid flow:** Application of first and second law of thermodynamics to turbo machines, Efficiencies of turbo machines, Static and Stagnation states, Incompressible fluids and perfect gases, overall isentropic efficiency, stage efficiency (their comparison) and polytropic efficiency for both compression and expansion processes. Reheat factor for expansion process	3	- L2 - L2	L2	Understand	- Lecture - -	- Assignment - -
2	General Analysis of Turbo machines: Radial flow compressors and pumps – general analysis, Expression for degree of reaction, velocity triangles, .	6	- L2 - L2	L2	Understand	- Lecture -	- Assignment -
2	Effect of blade discharge angle on energy transfer and degree of reaction, Effect of blade discharge angle on performance, Theoretical head – capacity relationship, General analysis of axial flow pumps and compressors, degree of reaction, velocity triangles, Problems.	4	- L2 - L2	L2	Understand	- Lecture -	- Assignment -
3	.Steam Turbines: Classification, Single stage impulse turbine, condition for maximum blade efficiency, stage efficiency,	4	- L2 - L2	L2	Understand	- Lecture -	- Assignment -
3	compounding, Multi-stage impulse turbine, expression for maximum utilization factor. Reaction turbine – Parsons’s turbine, condition for maximum utilization factor, reaction staging. Problems	6	- L2 - L2	L2	Understand	- Lecture - -	- Assignment - -
4	Hydraulic Turbines: Classification, various efficiencies. Pelton turbine – velocity triangles, design parameters, Maximum efficiency.	4	- L2 - L2	L2	Understand	- Lecture - -	- Assignment - -
4	Francis turbine - velocity triangles, design parameters, runner shapes for different blade speeds. Draft tubes- Types and functions. Kaplan and (10 Hours) Propeller turbines - velocity triangles, design parameters. Problems.	6	- L2 - L2	L2	Understand	- Lecture - -	- Assignment - -
5	Centrifugal Pumps: Classification and parts of centrifugal pump, different heads and efficiencies of centrifugal pump, Minimum speed for starting the flow, Maximum suction lift, Net positive suction head, Cavitation, Need for priming, Pumps in series and parallel.	6	- L2 - L2	L2	Understand	- Lecture - -	- Assignment - -
5	Centrifugal Compressors: Stage velocity triangles, slip factor, power input factor, Stage work, Pressure developed, stage efficiency and surging and problems. Axial flow Compressors: Expression for pressure ratio developed in a stage, work done factor, efficiencies and stalling. Problem	4	- L2 - L2	L2	Understand	- 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	Definition for TM Dimensionless parameters. Efficiency Reheat factor model studies	Precise definition Efficiency Reheat factor model studies	Dimensionless parameters. Efficiency Reheat factor model studies	Dimensionless parameters. Efficiency Reheat factor model studies	Understand	Definition for TM Dimensionless parameters. Efficiency Reheat factor model studies
2	Velocity triangle. Work done and energy transfer	Velocity triangle. Work done	energy transfer	Velocity triangle. Work done and energy transfer	Understand	Velocity triangle. Work done and energy transfer
3	Enthalpy change. stage efficiencies	Enthalpy change. stage efficiencies	Enthalpy change. stage efficiencies	stage efficiencies	Understand	Enthalpy change. stage efficiencies
4	Efficiency, design parameters.	Efficiency, design parameters.	Efficiency,	design parameters.	Understand Analyze	Efficiency, design parameters.
5	Power , work done factor, Efficiency.	Power , Efficiency.	, work done factor	work done factor, Efficiency.	Understand	Power , work done factor, Efficiency.