I

Name _____

Roll No. _____ Year 20____20____

Exam Seat No. _____

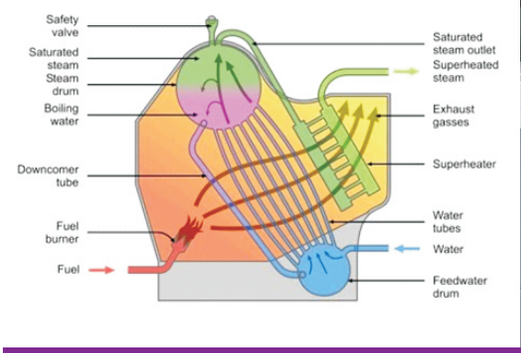
MECHANICAL GROUP | SEMESTER - III | DIPLOMA IN ENGINEERING AND TECHNOLOGY

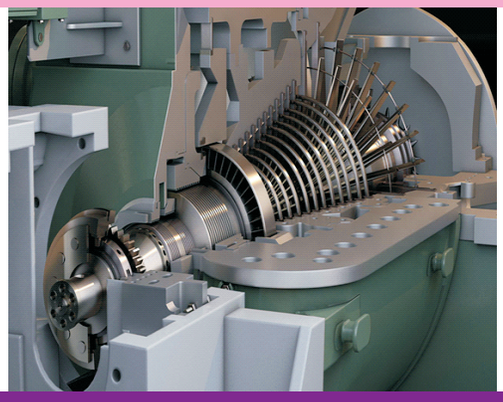
A LABORATORY MANUAL

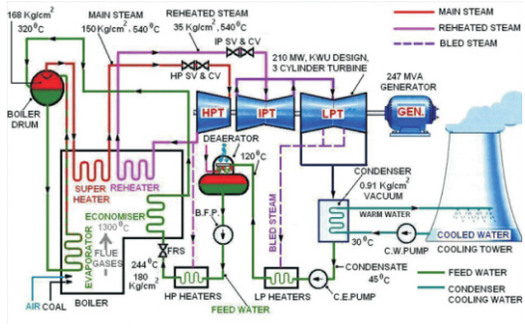
FOR

THERMAL ENGINEERING

(22337)







MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

(Autonomous) (ISO 9001 : 2015) (ISO / IEC 27001 : 2013)

VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the changing technological and environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the followings:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual

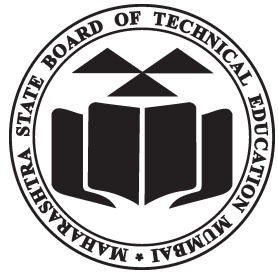
for

Thermal Engineering

(22337)

Semester-III

(ME/PT/PG)



Maharashtra State
Board of Technical Education, Mumbai
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Maharashtra State Board of Technical Education,
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4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai - 400051.
(Printed on June, 2018)

MAHARASHTRA STATE

BOARD OF TECHNICAL EDUCATION

Certificate

This is to certify that Mr. / Ms. ……..…… Roll No. ……..…., of Third Semester of Diploma in ……..…… of Institute, ……..……..… (Code: ……...) has completed the term work satisfactorily in course **Thermal Engineering (22337)** for the academic year 20…….. to 20…….. as prescribed in the curriculum.

Place: …… Enrollment No:.……

Date: …… Exam. Seat No: ……

Subject Teacher **Head of the Department** **Principal**

Seal of Institution

Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curricula for engineering diploma programmes with outcome-base education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practicals to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practicals to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Thermal engineering forms one of the core engineering subjects for mechanical engineering students. Diploma mechanical engineers (also called technologists) have to work with various power producing and power absorbing devices like boilers, turbines, compressor, I.C. engines, and refrigerators. The course will enable students to establish foundation required to design, operate and maintain these devices. Thermal power plants are still contributing major share in electricity production in India. This course emphasizes on steam boilers and allied components that are used in many industrial sectors. Students will be able to calculate various parameters required to determine the performance of these devices.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Programme Outcomes (POs) to be achieved through Practical of this Course

Following POs and PSOs are expected to be achieved through the practicals of the "Themal Engineering" course.

PO 1. **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Mechanical engineering problems.
PO 2. **Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
PO 3. **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.
PO 4. **Engineering tools:** Apply relevant Mechanical technologies and tools with an understanding of the limitations.
PO 6. **Environment and sustainability:** Apply Mechanical engineering solutions also for sustainable development practices in societal and environmental contexts.
PO 8. **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.
PO 10. **Life-long learning:** Engage in independent and life-long learning activities in the context of technological changes also in the Mechanical engineering and allied industry.

PSO 1. **Modern Software Usage:** Use latest Mechanical engineering related softwares for simple design, drafting, manufacturing, maintenance and documentation of mechanical engineering components and processes.
PSO 2. **Equipment and Instruments:** Maintain equipment and instruments related to Mechanical Engineering.
PSO 3. **Mechanical Engineering Processes:** Manage Mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, and operational parameters.

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List of Industry Relevant Skills

The following industry relevant skills of the competency **'Use principles of thermal engineering to maintain thermal related equipment.'** are expected to be developed in you by undertaking the practicals of this practical manual.

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. Follow ethical Practices.

Practical- Course Outcome matrix

Course Outcomes (COs)

a. Apply laws of thermodynamics to devices based on thermodynamics.
b. Use first law of thermodynamics for ideal gas in closed systems.
c. Use relevant steam boilers.
d. Use relevant steam nozzles and turbines.
e. Use relevant steam condensers.
f. Use suitable modes of heat transfer.

S. No.	Practical Outcome	CO a.	CO b.	CO c.	CO d.	CO e.	CO f.
1.	Measurement of discharge of air using air box.	√	√	-	-	-	-
2.	Trace the path of Flue Gases and Water Steam circuit of the boiler.	-	-	√	-	-	-
3.	Assembly and dismantling of boiler mountings.	-	-	√	-	-	-
4.	Assembly and dismantling of boiler accessories.	-	-	√	-	-	-
5.	Perform simulation of Thermal Power Plant and write specifications of boilers, turbines, condensers and electrical generators.	-	-	√	√	√	-
6.	Determination of dryness fraction of a given sample of steam by using separating calorimeter.	-	-	√	-	-	-
7.	Plot steam properties on Mollier chart for a given sample of wet steam.	-	-	√	-	-	-
8.	Assembly and dismantling of impulse and reaction turbines.	-	-	-	√	-	-
9.	Assembly and dismantling of cooling tower .	-	-	-	-	√	-
10.	Dismantle given model of surface condenser, draw sketches of various parts and assemble it.	-	-	-	-	√	-
11.	Conduct a trial on conduction setup for a metallic rod and calculate thermal conductivity.	-	-	-	-	-	√
12.	Identify different equipment in power engineering lab having heat exchangers and	-	-	-	-	-	√

	classify heat exchangers. Write construction and working any 03 of above heat exchangers.						
13.	Conduct trial to determine mass flow rate of one fluid using energy balance equation in heat exchanger.	**-**	**-**	**-**	**-**	**-**	√
14.	To determine convective heat transfer coefficient for the given fluid.	**-**	**-**	**-**	**-**	**-**	√
15.	Verify of Stefan-Bolzman constant for radiation.	**-**	**-**	**-**	**-**	**-**	√

Guidelines to Teachers -

1. Teacher need to ensure that a dated log book for the whole semester, apart from the laboratory manual is maintained by every student which s/he has to submit for assessment to the teacher in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters(if any), which is not mentioned in the printed practicals.
3. For difficult practicals if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. One or two questions ought to be added in each practical for different batches. For this teachers can maintain various practical related question bank for each course.
7. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
8. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
9. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
10. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines.
11. Experimental setups proposed are guidelines. Teacher can do better and give his valuable feedback to MSBTE on further improvements in manual.
12. Teachers shall use any suitable demo / open source simulation software available on internet.
13. Teachers have scope to simulate different conditions. They may add more such tables for different simulating conditions.
14. Experiment number 12 requires graph paper. Students can attach it externally if not provided in manual.

Instructions for Students

1. For incidental writing on the day of each practical session every student should maintain a dated log book for the whole semester, apart from this laboratory manual which s/he has to submit for assessment to the teacher in the next practical session.
2. For effective implementation and attainment of practical outcomes, in the beginning itself of each practical, students need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
3. Student ought to refer the data books, IS codes, Safety norms, Electricity act/rules, technical manuals, etc.
4. Student should not hesitate to ask any difficulties they face during the conduct of practicals.
5. Students are expected to perform the experiments in group (as applicable) where as calculations shall be made independently.

Content Page

List of Practicals and Progressive Assessment Sheet

S. No	Practical Outcome	Page No.	Date of performance	Date of submission	Assessment marks(25	Dated sign. of teacher	Remarks (if any)
1.	Measurement of discharge of air using air box.	1					
2.	Trace the path of Flue Gases and Water Steam circuit of the boiler.	8					
3.	Assembly and dismantling of boiler mountings.	13					
4.	Assembly and dismantling of boiler accessories.	18					
5.	Perform simulation of Thermal Power Plant and write specifications of boilers, turbines, condensers and electrical generators.	23					
6.	Determination of dryness fraction of a given sample of steam by using separating calorimeter.	29					
7.	Plot steam properties on Mollier chart for a given sample of wet steam.	34					
8.	Assembly and dismantling of impulse and reaction turbines (Model).	39					
9.	Assembly and dismantling of cooling tower.	44					
10.	Dismantle given model of surface condenser, draw sketches of various parts and assemble it.	49					
11.	Conduct a trial on conduction setup for a metallic rod and calculate thermal conductivity.	53					

12.	Identify different equipment in power engineering lab having heat exchangers and classify heat exchangers. Write construction and working any 03 of above heat exchangers.	59					
13.	Conduct trial to determine mass flow rate of one fluid using energy balance equation in heat exchanger.	65					
14.	To determine convective heat transfer coefficient for the given fluid.	70					
15.	Verify of Stefan-Bolzman constant for radiation.	76					
Total							

Note: To be transferred to Proforma of CIAAN-2017.

Practical No. 1: Measurement of discharge of air using air box.

I Practical Significance

Students will have to perform tests of reciprocating air compressors, IC engines, measurement of convective heat transfer coefficient. In all these cases calculation of air flow rate at the inlet of these devices is important. Students shall be able to calculate this flow rate which is expressed in m^3/s.

II Relevant Program Outcomes (POs)

PO1 - **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based electrical engineering problems.
PO3 **- Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Electrical engineering problems.
PO 8. **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.**

1. Measure parameters required to determine air flow rate.
2. Convert different units in to SI units.

IV Relevant Course Outcome(s)

- Use first law of thermodynamics for ideal gas in closed systems.

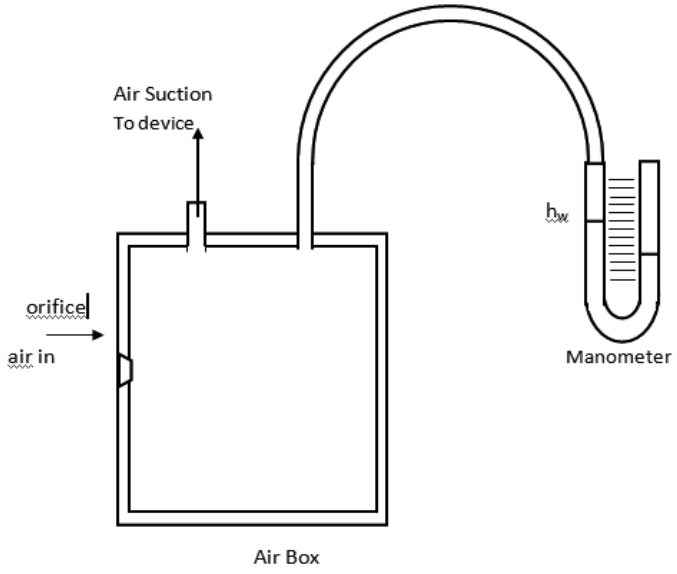
V Practical Outcome

- Determination of actual volume per second at the suction of reciprocating air compressor

VI Minimum Theoretical Background

Equation of state can be used to calculate density of air. This gives relation between pressure, volume and temperature of given ideal gas. Air can be approximated to ideal gas. This equation can be used in air compressors, IC engines to calculate volume flow rate of air at the inlet of these devices. In this first law steady state energy equation is applied across orifice through which air flows.

VII Circuit diagram / Setup



Air box arrangement

VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Reciprocating air compressor test rig	P = 10 bar N = 650 rpm	1 No.
2.			
3.			

IX Precautions to be Followed

1. Stay away from rotating components.
2. Check oil level in compressor before it is started.

X Procedure

1. Start the air compressor
2. Run it till tank pressure becomes 2 bar
3. Open air exit valve so that tank pressure will not rise further.
4. Take manometer reading
5. Calculate air flow rate in m^3/s
6. Repeat the same for pressures of incremental 2 bar pressure steps.

XI Resources Used

S. No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XII Actual Procedure Followed

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……
……

XIII Precautions Followed

……
……
……

XIV Observations and Calculations

S.N.	Pressure in tank	h_1	h_2	$h_w = h_1 - h_2$
1	2 bar			
2	4 bar			
3	6 bar			
4	8 bar			

Air is ideal gas. Use equation of state to find density of air.

$P_aV_a = mRT_a$

$\mathbf{Q}_a = m / V_a = P_a / RT_a$ = ……. m^3/kg

$$h_a\mathbf{Q}_a = h_w\mathbf{Q}_w$$

A_o = Area of orifice = πr_o^2 = ……..m^2

According to steady flow energy equation applied across orifice

$(u_1 + P_1v_1 + V_1^2 / 2 + Z_1g \pm Q) = (u_2 + P_2v_2 + V_2^2 / 2 + Z_2g \pm W)$

$Q = 0$; $W = 0$; $u_1-u_2 = 0$; $z_1g – z_2g = 0$

$P_1v_1 + V_1^2 / 2 = P_2v_2 + V_2^2 / 2$

Multiplying both sides by $1/g$ & $v = 1/\mathbf{Q}$ and rearranging terms

$P_1/ \mathbf{Q}g - P_2 / \mathbf{Q}g = V_2^2 / 2g - V_1^2 / 2g$

$h_a = V_2^2 / 2g$ neglecting V_1

$V_2 = \sqrt{2gh_a}$

Discharge of air is
$Q = C_d*A* V_2$

Discharge here is denoted by
$Va = C * A * \sqrt{2gh_a}$

$V_a = C_dA_o\sqrt{(2gh_a)}$ = …….. m^3/s

XV Results

S.N.	Pressure in tank	Volume flow rate (V_a), m^3/s
1	2 bar	
2	4 bar	
3	6 bar	
4	8 bar	

XVI Interpretation of Results

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XVII Conclusions

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XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Write equation of state and state meaning of all terms involved with their units.
2. If pressure of atmosphere changes what will be effect on volume flow rate of air at the inlet of compressor?
3. What are the units of pressure mentioned on pressure gauges? State their conversion factors to convert them in to bar.

(Space for Answer)

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XIX References / Suggestions for Further Reading

a. http://www.em-ea.org/guide%20books/book-3/chapter%203.3%20compressed%20air%20system.pdf

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Measurements using different instruments	20%
2	Calculations involved	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……..……..
2. ……
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 2: Trace the path of Flue Gases and Water Steam circuit of the boiler.

I Practical Significance

Boilers are widely used in various applications in industry viz. thermal power plants, dairy, sugar industry, rubber industry, textile industry etc. To operate boilers it is necessary to locate path of steam and gases. This will enable students to maintain boilers effectively and efficiently.

II Relevant Program Outcomes (POs)

PO2 **- Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO3 **- Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.

PO6 **- Environment and sustainability:** Apply Mechanical engineering solutions also for sustainable development practices in societal and environmental contexts.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.**':

1. Maintain tool and equipments.
2. Practice energy conservation**.**

IV Relevant Course Outcome(s)

- Use relevant steam boilers.

V Practical Outcome

- Trace the path of Flue Gases and Water Steam circuit of the boiler.

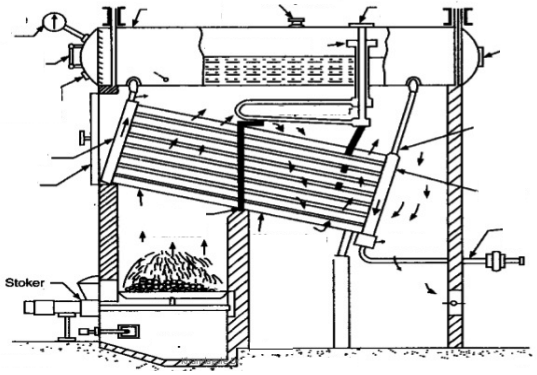
VI Minimum Theoretical Background

Boiler which are also known as steam generator has main components like furnace / combustion chamber, drum for storing steam & water, heating tubes, economizers, super heaters. Coal or oil is main fuel which is burned to heat the water. Gases are sent to atmosphere using chimney.

VII Setup (Models) -

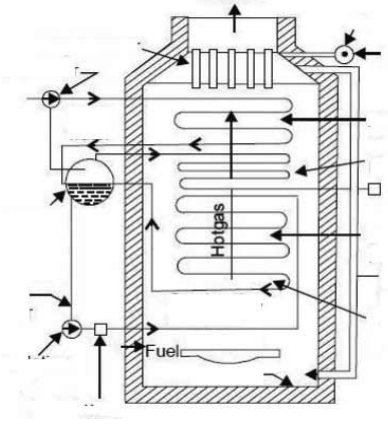
Name of boiler - ……..

(Note – Draw the sketch of the model of Babcock & Wilcox boiler available in your laboratory and label the components. In case components are not visible redraw and label the figure given below)



Name of boiler - ……..

(Note – Draw the sketch of the model of Lamont boiler available in your laboratory and label the components. In case components are not visible redraw and label the figure given below)



VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Models of Boiler	Laboratory Models of fire tube and water tube boilers	1 No.
2.			
3.			

IX Precautions to be Followed

1. Use safety shoes.
2. Do not try to dismantle model of boiler forcefully.

X Procedure

1. Select boiler model for demonstration.
2. Locate path of water and steam from inlet to outlet.
3. Locate path of air, fuel and gases.
4. Locate these paths with arrowheads on given figures with different colors.
5. Draw sketches of other any two boilers indicating above paths.
6. Write specifications of different boilers.

XI Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XII Actual Procedure Followed

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XIII Precautions Followed

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XIV Observations and Calculations

For any two boilers trace the path of flue gases and steam and enter in given table.

Boiler	S. No.	Components in sequence through which steam is generated	S. No.	Components in sequence through which gases pass

XV Results

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XVI Interpretation of Results (Giving meaning to results)

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XVII Conclusions (Actions to be taken based on the interpretations.)

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XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State applications of water tube boilers.
2. State applications of fire tube boilers.
3. Which boilers are called as high pressure boilers?
4. Suggest some changes in arrangement of different components / path of steam or gases to make it more efficient.
5. List manufacturers of boilers with applications.
6. Write specifications of a typical boiler.
7. What is need of boiler blow down?
8. What is composite boiler?
9. Draw sketches of two more boilers.

(Space for Answer)

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XIX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=7Y8gwjLdtww (Babcock & Wilcox video)
2. https://www.youtube.com/watch?v=uFH4ZrM48BE (Lamont Boiler video)

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Identifying main components of boiler	20%
2	Locating path of steam and gases.	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ..……..……..
2. ……..…….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 3: Assembly and dismantling of boiler mountings.

I Practical Significance

Boiler mountings are compulsory parts of boiler as per Indian Boiler Act, 1923. Boilers cannot function without mountings. Safe operation of boilers depends on use of mountings. There are two types of mountings viz. control mountings and safety mountings.

II Relevant Program Outcomes (POs)

PO2 **- Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
PO3 **- Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.
PO8 **- Individual and team work:** Function effectively as a leader and team member in diverse / multidisciplinary teams.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.**':

1. Follow safety practices
2. Locate the position of mounting**.**

IV Relevant Course Outcome(s)

- Use relevant steam boilers.

V Practical Outcome

- Assembly and dismantling of boiler mountings.

VI Minimum Theoretical Background

Different mountings of boilers mainly include safety mountings like safety valve, water level indicator, fusible plug, pressure gauge and control mountings like feed check valve, steam stop valve and blow off cock. Maintenance of these boiler mountings is important for safe working of boilers.

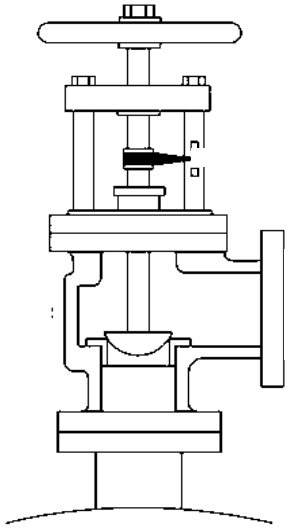
VII Setup (Models) -

Name of mounting - ……..

(Note – Draw the sketch of the actual mounting / model of mounting of boiler available in your laboratory and label the components. In case components are not visible redraw and label the figure given below)

Name of mounting - ……..

(Note – Draw the sketch of the actual mounting / model of mounting of boiler available in your laboratory and label the components. In case components are not visible redraw and label the figure given below)



VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Commonly used mounting.	Mountings that can be assembled and dismantled.	1 each
2.			
3.			
4.			

IX Precautions to be Followed

1. Use safety shoes.
2. Maintain tools and equipments.

X Procedure

1. Select boiler mounting(s) available for dismantling. location
2. Locate selected mounting on the boiler model.
3. Write function of the mounting in given table.
4. Dismantle the same using tools.
5. List the parts and state the function of each part in given table.
6. Locate different areas need maintenance / replacement.
7. Assemble the same again.

XI Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XII Actual Procedure Followed

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XIII Precautions Followed

.....

.....

XIV Observations and Calculations

S. No	Mounting	Location & Function	Parts of the given mounting	Maintenance issues located
1				
2				
3				
4				
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Some of the typical maintenance related issues in different mountings can be as follows

- Check condition of internal parts of valve for sign of corrosion, galling and wear.
- Check for pitting, cracking, resiliency, and condition of springs.
- Check spindle for straightness and adjusting ring threads for freedom of movement.
- Check the discharge and drain piping, it should be well clear.
- Check dampers to ensure that linkages are secured and well-greased.
- Check condition and operation of all feed water, blow down, drain, and other valves.

XV Results

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XVI Interpretation of Results (Giving meaning to results)

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XVII Conclusions (Actions to be taken based on the interpretations.)

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XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. What should be discharge capacity of safety valve?
2. What shall be maximum set pressure of safety valve?
3. Write materials of different parts used in Steam Stop Valve.
4. Which type of safety valve is used in high pressure and low pressure boilers?

(Space for Answer)

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XIX References / Suggestions for Further Reading

1. http://www.spiraxsarco.com/Resources/Pages/Steam-Engineering-Tutorials/the-boiler-house/boiler-fittings-and-mountings.aspx
2. http://www.brighthubengineering.com/marine-engines-machinery/73157-inspection-of-boiler-mountings/
3. https://www.youtube.com/watch?v=yi7gJuwLGYk (Safety valve assembly)

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Identifying main parts of mounting.	20%
2	Locate different areas of maintenance.	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……..
2. ……..….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 4: Assembly and dismantling of boiler accessories (Using dissectible model)

I Practical Significance

Boiler accessories are meant for increasing efficiency of boiler and allied thermal engineering system. They are not necessary for boilers to function. However energy conservation is important aspect of any thermal engineering system. Accessories take care of the same.

II Relevant Program Outcomes (POs)

PO2 **- Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
PO3 **- Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.
PO8 **- Individual and team work:** Function effectively as a leader and team member in diverse / multidisciplinary teams.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.'** :

1. Practice Energy conservation.
2. Use of tools & equipments.

IV Relevant Course Outcome(s)

- Use relevant steam boilers.

V Practical Outcome

- Assembly and dismantling of boiler Accessories.

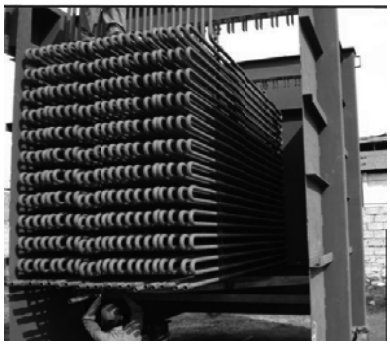
VI Minimum Theoretical Background

Boiler accessory like air pre-heater, economizer acts as heat recovery unit and extracts heat from flue gases from boiler. Super heater is employed for increasing work output from available steam as well as take of possible condensation in steam turbine thereby avoiding erosion and corrosion of turbine blades.

VII Setup (Models) -

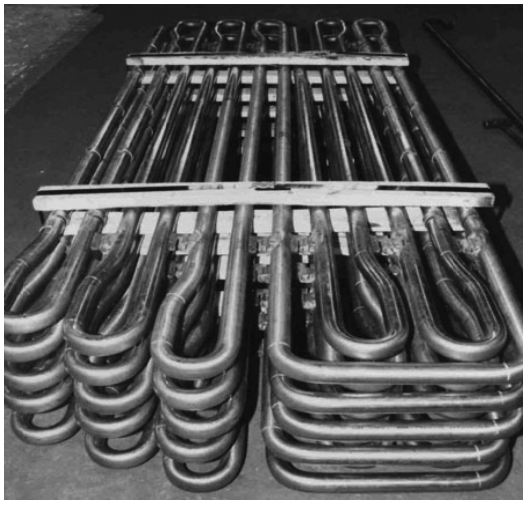
Name of accessory - Superheater

(Note – Draw the sketch of the actual superheater / model of superheater of boiler available in your laboratory and label the components. In case components are not visible redraw and label the figure given below)



Name of accessory – Economiser

(Note – Draw the sketch of the actual economiser / model of economiser of boiler available in your laboratory and label the components. In case components are not visible redraw and label the figure given below)



VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Suitable size accessories.	Accessories that can be assembled and dismantled.	1 each
2.			

IX Precautions to be Followed

1. Use safety shoes.
2. Do not try to dismantle accessories forcefully.

X Procedure

1. Select boiler accessory (ies) available for dismantling.
2. Dismantle the same using tools.
3. Understand functions of different parts.
4. Locate different areas need maintenance / replacement.
5. Assemble the same again.

XI Resources Used

S. No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XII Actual Procedure Followed

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XIII Precautions Followed

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XIV Observations and Calculations

S. No	Accessory	Location & Function	Parts of the given accessory	Maintenance issues located
1				
2				
3				
4				
5				
6				

Some of the typical maintenance related issues in economizer can be as follows

- Inspect tubes for bend or deformation
- Inspect heat transfer surface & anti wear tiles for wear or crack.
- Inspect tail elbows, straight tubes for wear out, burn etc.
- Measure elbows, tubes or U bends thickness.
- Inspect row deformation which will affect flue gas corridor.
- The major problem at the economizer section is low temperature corrosion and problems from gas side deposits.
- Sliding and leaky expansion joints at the casing may allow accumulation of soot with severe acid attack.

Some of the typical maintenance related issues in superneater can be as follows

- Check tubes, tube clips, positioning
- Check tubes for oxidation, bend, corrosion, wear, crack etc.
- Measure diameters of tube using Vernier caliper and note them
- Peel of oxidation layer from mid section of a tube.
- Measure thickness of oxidation layer using micrometer and note it.
- Check protection tiles, tube clips and positioning plates for missing or burning or falling.

XV Results

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XVI Interpretation of Results (Giving meaning to results)

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XVII Conclusions (Actions to be taken based on the interpretations.)

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XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State advantages of economizer.
2. State advantages of air pre-heater.
3. State other application areas of economizer.
4. What are non-condensing type economizers?
5. What are different super-heaters commonly used in power plants?
6. What is use of de-superheater in super-heater?

(Space for Answer)

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XIX References / Suggestions for Further Reading

1. https://books.google.co.in/books?id=xJUqDwAAQBAJ&q=superheater&source=gbs_word_cloud_r&cad=5#v=snippet&q=superheater&f=false (google book on boiler maintenance)
2. http://www.brighthubengineering.com/marine-engines-machinery/74949-inspection-carried-out-in-boiler-superheater-and-in-steam-drum/ (super-heater cleaning)
3. https://www.youtube.com/watch?v=y4anGmVTd-M (economizer cleaning)

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Identifying main parts of accessories.	20%
2	Locate different areas of maintenance.	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 5: Simulation of Thermal Power Plant

I Practical Significance

A typical thermal power plant has several components. Online free / demo software are available for students which allow students to change certain parameters of typical power plant and observe changes in other parameters. Carrying out simple simulations optimized solutions can be generated.

II Relevant Program Outcomes (POs)

PO2 - **Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
PO3 - **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.
PO4 - **Engineering tools:** Apply relevant Mechanical technologies and tools with an understanding of the limitations.
PO10 - **Life-long learning:** Engage in independent and life-long learning activities in the context of technological changes also in the Mechanical engineering and allied industry.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.'** :

1. Use simulation software.
2. Maintain tools and equipments.

IV Relevant Course Outcome(s)

- Use relevant steam boilers.

V Practical Outcome

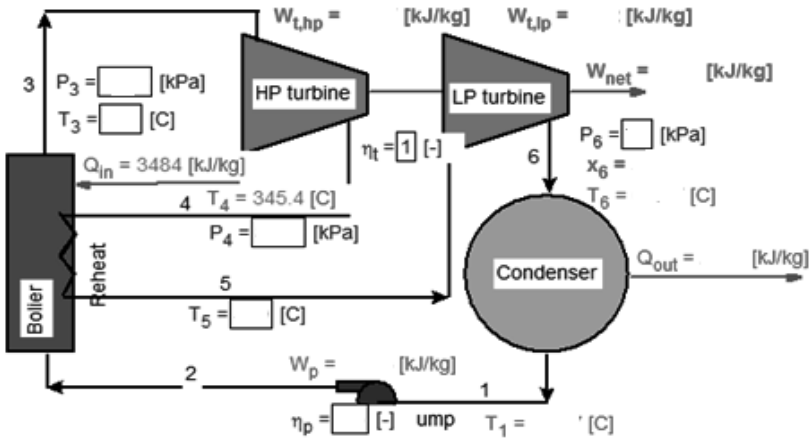
- Perform simulation of Thermal Power Plant and write specifications of boilers, turbines, condensers and electrical generators.

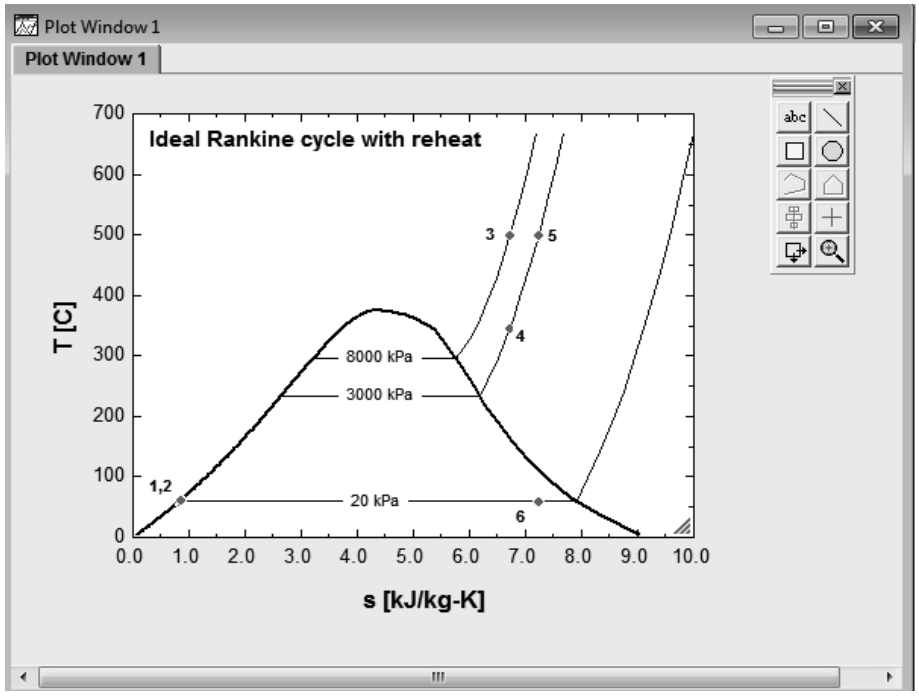
VI Minimum Theoretical Background

Thermal power plant consists of different components like boiler, turbine, condenser, feed pumps, de-aerators, re-heaters etc. Several parameters like boiler pressure, boiler temperature, reheat temperatures affect on the performance of the thermal power plant and plant efficiency changes accordingly. EES (Engineering Equation Solver) or Cycle tempo or MATLAB are some simulation software available online with free demo versions.

VII Setup (Software) -

Name of software – Any suitable software – Demo Version





VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	Suitable software	Demo version	1
2.	Computer Laboratory with PCs	Latest configuration	20 Nos.
3.			
4.			

IX Precautions to be Followed

1. Do not use pirated copies of any software.
2. Change values of one parameter at a time initially to observe output changes.

X Procedure

1. Open website www.fchart.com
2. Download Demo Version of EES.
3. Go to "***Examples***" in main menu. You will get a drop down menu list.
4. Click on "***getting started with EES***"
5. Click on "***Steam cycle – diagram window input***"
6. You will find one already framed problem on steam power plant in *"Equations window"*
7. Learn equations window.
8. Go to "***Windows***" in main menu.
9. Click on "***Diagram window***"
10. You will get a diagram window for a steam power plant.
11. Again go to "***Windows***" in main menu
12. Click on "***Plot window***"
13. You will get T-s Plot for the given problem on your screen.
14. Now you can **vary different parameters** on the diagram window and observe changes in other parameters.
15. Prepare excel sheet tables for different inputs you have given and changes in rest of the parameters
16. Comment on the results (minimum 04 comments)
17. Create some more examples at your own.

XI Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XII Actual Procedure Followed

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XIII Precautions Followed

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XIV Observations and Calculations – (Teacher may change it as per requirement)

P_3 KPa	T_3 ^oC	W_T HP kJ/kg	W_T LP kJ/kg	W_{net} kJ/kg	Q_{out} kJ	Cycle efficiency

XV Results

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XVI Interpretation of Results (Giving meaning to results)

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XVII Conclusions (Actions to be taken based on the interpretations.)

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XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Draw P-h and T-s diagram for Rankine cycle.
2. If you increase reheat temperature what will be effect on dryness fraction at the exit of turbine?
3. Comment on use of parametric tables in this software.
4. Design two more such observation tables given In part XIV of the experiment.
5. Calculate the values given by EES using steam tables.

(Space for Answer)

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XIX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=XTkPElH_h3k
2. https://www.youtube.com/watch?v=nyLPOAEYTOs
3. https://www.youtube.com/watch?v=nvAziprQSOM
4. https://www.youtube.com/watch?v=in45SAFIUKw

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Simulating various parameters within appropriate ranges satisfactorily	20%
2	Tabulate results independently.	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 6: Determination of dryness fraction of steam

I. Practical Significance

In industries who use steam for various purposes need to find out dryness fraction for determining condition of steam. Particles of water in steam can have greater impact on various devices. In steam turbines the presence of water particle can result in erosion as well as corrosion of blades of turbine. Wet steam is economical in certain cases.

II. Relevant Program Outcomes (POs)

PO2 **- Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
PO3 **- Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.
PO6 **- Environment and sustainability:** Apply Mechanical engineering solutions also for sustainable development practices in societal and environmental contexts.

III. Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.**':

- Follow safety practices.
- Practice energy conservation.

IV. Relevant Course Outcome(s)

- Use relevant steam boilers.

V. Practical Outcome

- Determination of dryness fraction of a given sample of steam by using separating calorimeter.

VI. Minimum Theoretical Background

The steam containing water particles is called as wet steam. Steam calorimeters are devices used to find dryness fraction of the steam. In separating calorimeters water particle are separated mechanically. The steam is allowed to strike on hard surface due to which water particles falls down. The steam is separately collected in another chamber. The weight s of water particles and steam are measured.

VII. Setup (Models) -
(Label the sketch)

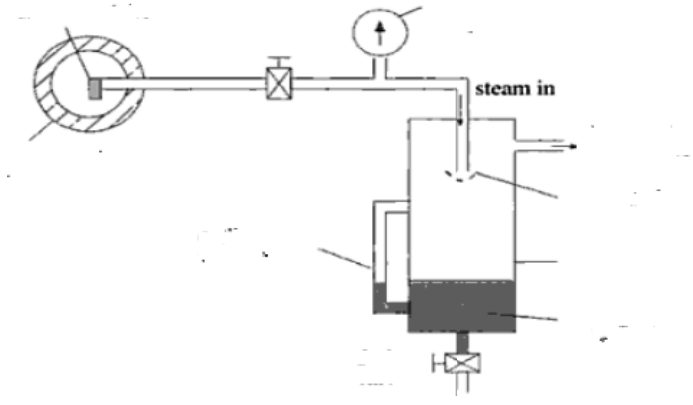

Figure – Seperating Calorimeter

VIII. Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Experimental setup to find dryness fraction of steam.	Steam generator with separating calorimeter. Steam generator equipped with pressure and temperature gauges.	1 No.
2			
3			

IX. Precautions to be Followed

1. Use safety shoes.
2. Monitor pressure gauge for safe operation of steam generator.

X. Procedure

1. Start the steam generator.
2. Note the pressure and temperature of steam generator.
3. Open the steam valve for few seconds and send the sample to calorimeter.
4. Measure mass of condensate collected.
5. Measure mass of dry steam separately.

XI. Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XII. Actual Procedure Followed

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XIII. Precautions Followed

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XIV. Observations and Calculations

S. No.	Pressure bar	Mass of water (M_w) kg	Mass of dry steam (M_s) kg	Dryness fraction
1				
2				

Dryness fraction is calculated by formula (Calculate at different pressures)

$$x = M_s / (M_s + M_w)$$

XV. Results

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XVI. Interpretation of Results (Giving meaning to results)

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XVII. Conclusions (Actions to be taken based on the interpretations.)

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XVIII. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State limitation of separating calorimeter.
2. Explain principle of separating and throttling calorimeter.
3. State formula to determine enthalpy of steam when it contain water particles.
4. List applications where wet steam is used.
5. Calculate dryness fraction for different pressures.

(Space for Answer)

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XIX. References / Suggestions for Further Reading

1. https://forums.ni.com/t5/Projects-Products/Design-and-Development-of-Virtual-Experimental-Set-up-To/ta-p/3525961
2. https://ecoursesonline.icar.gov.in/mod/page/view.php?id=2420

XX. Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Operating experimental setup satisfactorily	20%
2	Calculating dryness fraction independently.	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 7: Use of Mollier chart to find enthalpy of steam.

I Practical Significance

Mollier chart is also known as enthalpy entropy chart. Properties of steam which can be calculated with steam table can also be calculated graphically using Mollier chart. It saves calculations required when steam table is used.

II Relevant Program Outcomes (POs)

PO2 **- Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
PO3 **- Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.
PO6 **- Environment and sustainability:** Apply Mechanical engineering solutions also for sustainable development practices in societal and environmental contexts.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.**':

- Follow safety practices.
- Practice energy conservation.

IV Relevant Course Outcome(s)

- Use relevant steam boilers.

V Practical Outcome

- Plot steam properties on Mollier chart for a given sample of wet steam.

VI Minimum Theoretical Background

Vertical lines on Mollier chart mark entropy of steam in kJ/kg K. Horizontal lines indicate enthalpy in kJ/kg. Also there are constant pressure lines running across the chart. Constant temperature lines can be observed in vapour region whereas constant dryness fraction lines can be observed in wet region. Knowing any two properties the state of the steam can be located on Mollier chart.

VII Setup (Models)

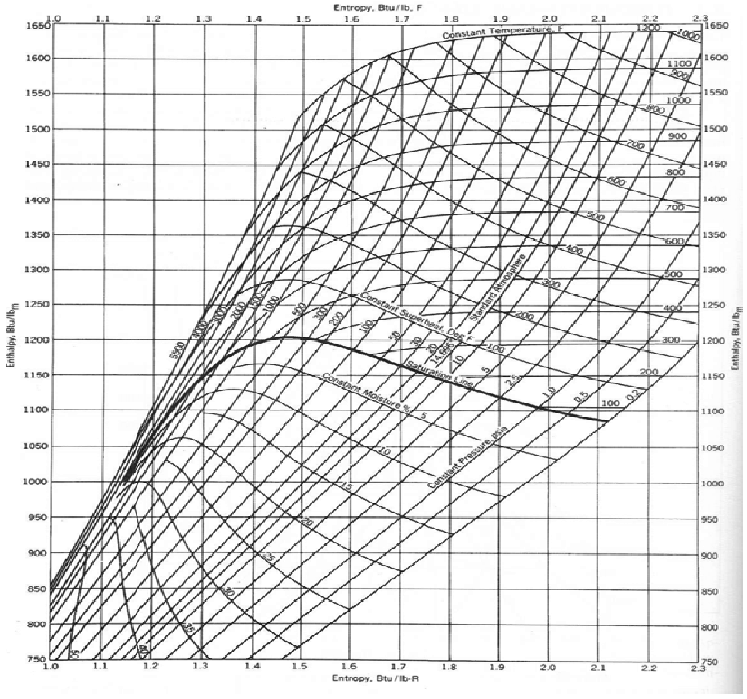

Figure – Mollier chart

VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Experimental setup to find dryness fraction of steam.	Steam generator with separating calorimeter. Steam generator equipped with pressure and temperature gauges. *Students to carry Mollier chart.	1 No.
2			
3			

IX Precautions to be Followed

1. Use safety shoes.
2. Monitor pressure gauge for safe operation of steam generator.

X Procedure

1. Start the steam generator.
2. Note the pressure and temperature of steam generator.
3. Open the steam valve for few seconds and send the sample to calorimeter.
4. Measure mass of condensate collected.
5. Measure mass of dry steam separately.
6. Locate the point on Mollier chart using pressure and dryness fraction calculated.
7. Use different pressures and repeat the same procedure.

XI Resources Used

S. No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XII Actual Procedure Followed

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XIII Precautions Followed

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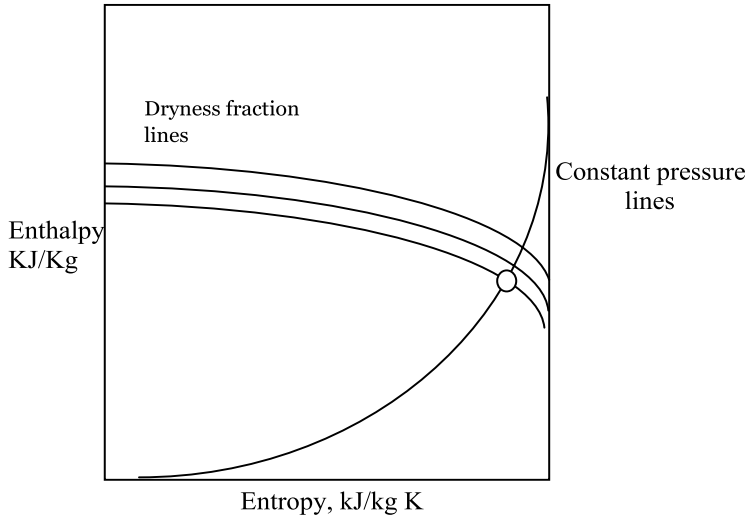
XIV Observations and Calculations

S. No.	Pressure bar	Dryness fraction	Enthalpy (h) kJ/kg	Entropy (s) kJ/kg K
1				
2				

Dryness fraction is calculated by formula

$$X = M_s / (M_s + M_w)$$



After locating point on Mollier chart enthalpy of steam was found to be h = ……. kJ/kg

XV Results

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XVI Interpretation of Results (Giving meaning to results)

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XVII Conclusions (Actions to be taken based on the interpretations.)

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XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Draw a Mollier chart showing different properties on the same
2. Represent various steam processes on Mollier chart.
3. State advantages and limitations of Mollier chart.
4. State the reason of using saturated steam in most applications?
5. Compare enthalpy in 03 different cases by using steam table and Mollier chart for same data for steam.

(Space for Answer)

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XIX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=ZKVs0FvfgP4
2. https://ecoursesonline.icar.gov.in/mod/page/view.php?id=2410

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Locating steam condition on Mollier chart.	30%
2	Finding values of enthalpy and entropy.	10%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 8: Assembly and dismantling steam turbines (Using dissectible / working model)

I Practical Significance

Steam turbines are important device in thermal engineering. Steam turbines are employed as the prime movers together with the electric generators in thermal and nuclear power plants to produce electricity. They are also used to propel large ships, ocean liners, submarines and to drive power absorbing machines like large compressors, blowers, fans and pumps.

II Relevant Program Outcomes (POs)

PO2 **- Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
PO3 **- Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.
PO6 **- Environment and sustainability:** Apply Mechanical engineering solutions also for sustainable development practices in societal and environmental contexts.
PO 8. **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.**':

- Demonstrate working as a leader/a team member.
- Maintain tools and equipments

IV Relevant Course Outcome(s)

- Use relevant steam nozzles and turbines.

V Practical Outcome

- Assembly and dismantling of impulse and reaction turbines.

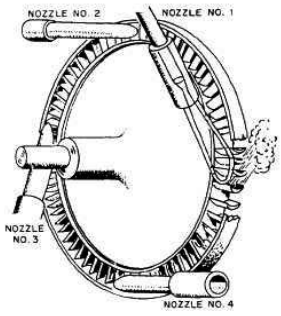
VI Minimum Theoretical Background

Impulse turbine has nozzles and moving blades. The nozzles are convergent-divergent type while moving blades are symmetrical in shape. Reaction turbines employs aerofoil shaped blades. The shapes of fixed as well as moving blades are same.

VII Setup (Models) -

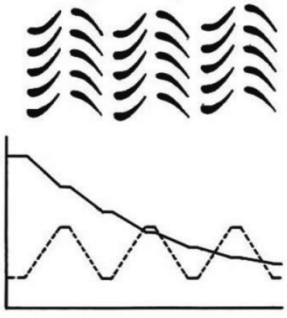
Name of Turbine - ……..

(Note – Name the components)



Name of turbine - ……..

(Note – Name the components)



VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Impulse Turbine	Impulse turbine of suitable size which can be dismantled and assembled.	1 No.
2	Reaction Turbine	Reaction turbine of suitable size which can be dismantled and assembled.	1 No.
3			

IX Precautions to be Followed

- Use safety shoes.
- Use tools carefully.

X Procedure

1. Select turbine model for demonstration.
2. Dismantle the same using suitable tools.
3. Locate different components of the given turbine.
4. Locate different damage / failure areas in given turbine.
5. Assemble the same again.

XI Resources Used

S.No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1					
2					
3					

XII Actual Procedure Followed

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XIII Precautions Followed

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XIV Observations and Calculations

Type of turbine selected – Impulse

S. No.	Components in sequence dismantled	Type	Material	Tool used	Possible failure / damage
1	Turbine blades	Impulse / reaction			Erosion/ corrosion
2	Turbine Rotor				
3	Diaphragm				
4	Turbine casing				
5	Bearings				
6	Turbine seals				
7					

Type of turbine selected – Reaction

S. No.	Components in sequence dismantled	Type	Material	Tool used	Possible failure / damage
1	Turbine blades	Impulse / reaction			Erosion/ corrosion
2	Turbine Rotor				
3	Turbine casing				
4	Bearings				
5	Turbine seals				
6					

XV Results

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XVI Interpretation of Results (Giving meaning to results)

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XVII Conclusions (Actions to be taken based on the interpretations.)

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XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Collect specifications of steam turbines used for different applications (Refer Siemens website).
2. State ten differences between impulse and reaction turbines.
3. Collect data of steam turbines used in non-conventional power sector.
4. Explain backpressure turbines.
5. Collect information on steam turbine blade failure.

(Space for Answer)

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XIX References / Suggestions for Further Reading

1. https://www.eolss.net/sample-chapters/C08/E3-10-03-02.pdf
2. https://www.geoilandgas.com/sites/geog.dev.local/files/1261.pdf
3. https://www.gepower.com/steam/steam-turbines
4. http://www.steamforum.com/pictures/wgp4205%20Turbine.pdf
5. http://www.mechanicalengineeringsite.com/steam-turbine-basic-parts/

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Identifying main components of turbines	20%
2	Dismantling & assembling turbines	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 9:Assembly and dismantling of cooling towers (Using dissectible model).

I Practical Significance

Cooling towers have carried area of applications. Various applications like thermal power plants, sugar factories, air-conditioning plants etc. use cooling towers. Newer materials in construction of cooling towers are being introduced now-a-days. Efficient operation of cooling tower improves efficiency of entire plant.

II Relevant Program Outcomes (POs)

PO1 **- Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Mechanical engineering problems.
PO2 **- Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
PO3 **- Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.
PO8 **- Individual and team work:** Function effectively as a leader and team member in diverse / multidisciplinary teams.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.**':

- Identify different types of cooling towers.
- Locate different parts of cooling towers**.**

IV Relevant Course Outcome(s)

- Use relevant steam condensers.

V Practical Outcome

- Assembly and dismantling of cooling tower (Model).

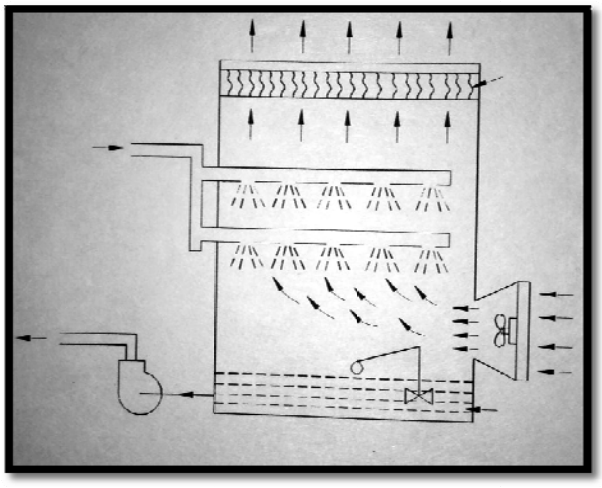
VI Minimum Theoretical Background

For condensing steam in different applications continuous supply of cold water is required. If this water source is not available nearby in abundant manner, re-circulation of water is necessary. This is possible using cooling towers. In cooling towers condenser cooling water is cooled again. Principle of evaporative cooling is used in during this process. Atmospheric air is used for cooling the condensate cooling water. Depending on way of cooling they are classified as natural draft and forced draft cooling towers.

VII Setup (Models) -

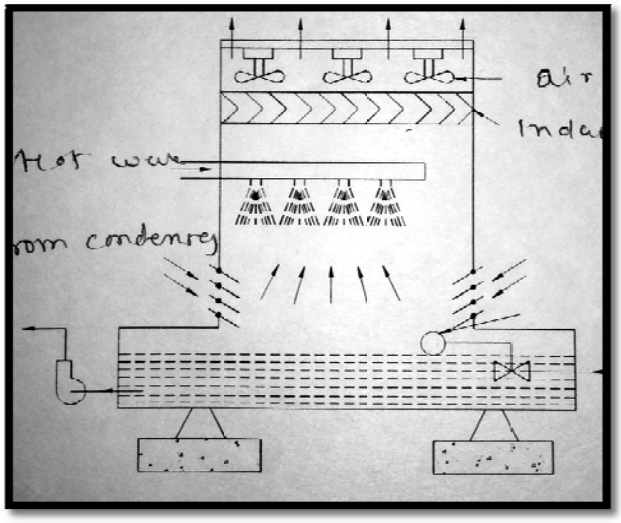
Name of cooling tower - ……..

(Note – Label different components)



Name of cooling tower - ……..

(Note – Label different components)



VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
	Models of cooling towers	Suitable size those can be dismantled and assembled in laboratory.	1 each

IX Precautions to be Followed

- Use safety shoes.
- Follow standard procedures for dismantling.

X Procedure

1. Select cooling tower available for dismantling.
2. Dismantle the same using tools.
3. List the parts and state the function of each part in given table.
4. Locate different areas need maintenance / replacement.
5. Assemble the same again.

XI Resources Used

S. No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		

XII Actual Procedure Followed

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XIII Precautions Followed

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XIV Observations and Calculations

S. No.	Name of part	Function of part	Material	Maintenance required
1	Eliminator			
2	Fan			
3	Motor			
4	Fill Material			
5	Casing			
6	Cold water basin			
7	Louvers			
8				

XV Results

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XVI Interpretation of Results (Giving meaning to results)

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XVII Conclusions (Actions to be taken based on the interpretations.)

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XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State principle of evaporative cooling.
2. Compare natural draft and forced draft cooling towers.
3. Compile information on currently used materials used for cooling towers.
4. Write cooling towers specifications.

(Space for Answer)

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XIX References / Suggestions for Further Reading

1. http://www.idconline.com/technical_references/pdfs/chemical_engineering/Cooling_Tower_Components.pdf
2. http://www.allkoteliningincaz.com/cooling-tower-components-cooling-tower-parts-functions/
3. http://www.enexio.com/water-technologies/products/cooling-tower-components/
4. http://www.nptel.ac.in/courses/103106101/Module%20-%208/Lecture%20-%202.pdf

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Identifying main parts of cooling towers.	20%
2	Locate different areas of maintenance.	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 10: Assembly and dismantling of surface condenser.

I Practical Significance

Surface condensers are preferred in large capacity power plants. Surface condenses are suitable for large range of applications due to their inherent advantages. In surface condensers poor quality cooling water can be used along with higher vacuum can be maintained. However they occupy more space and their initial & maintenance costs are more.

II Relevant Program Outcomes (POs)

PO2 **- Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
PO3 **- Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.
PO8 **- Individual and team work:** Function effectively as a leader and team member in diverse / multidisciplinary teams.
PO9 **- Communication:** Communicate effectively in oral and written form.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.**':

- Identify different types of surface condenser.
- Dismantle and assemble given surface condenser**.**

IV Relevant Course Outcome(s)

- Use relevant steam condensers.

V Practical Outcome

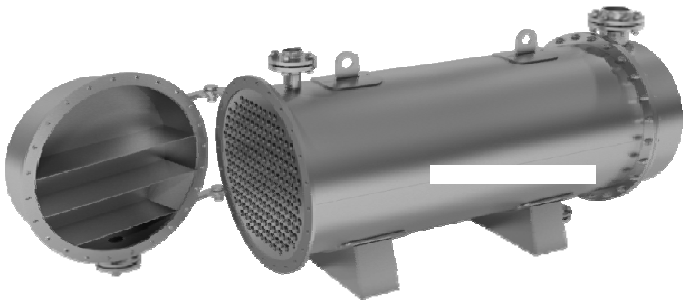
- Dismantle given model of surface condenser, draw sketches of various parts and assemble it.

VI Minimum Theoretical Background

In surface condenser, one fluid flows through tubes, where as another fluid flows over shell side. There is indirect contact of hot and cold fluid. Depending upon number of times tube length is travelled by fluid they are classified as single pass / double pass /multi pass. They can also be classified as center flow and down flow depending upon location of air pump.

VII Setup (Models) -

(Note – Label different components)



VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
	Surface condenser	Suitable size	1 each

IX Precautions to be Followed

- Use safety shoes.
- Arrange parts neatly to help quick assembly.

X Procedure

1. Select condenser available for dismantling.
2. Dismantle the same using tools.
3. Locate different parts and write their functions
4. Locate different areas need maintenance / replacement.
5. Assemble the same again.

XI Resources Used

S. No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		

XII Actual Procedure Followed

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XIII Precautions Followed

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XIV Observations and Calculations

S. No	Components	Function	Material	Tools used	Maintenance issues identified
1	Shell				
2	Shell expansion joint				
3	Tube support plates				
4	Tube sheets				
5	Tubes				
6	Waterbox				
7	Pass partitions				

XV Results

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XVI Interpretation of Results (Giving meaning to results)

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XVII Conclusions (Actions to be taken based on the interpretations.)

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XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Draw a typical condensing plant
2. State Dalton's law of partial pressure.
3. State purpose of air pump in surface condenser
4. State difference between surface and jet condenser.
5. Draw a schematic diagram of typical surface condenser showing all components.
6. How tube leakage in condensers can be detected.

(Space for Answer)

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XIX References / Suggestions for Further Reading

- https://www.youtube.com/watch?v=y5015p2QSx8
- https://www.youtube.com/watch?v=lSR5dhRFA9E
- https://www.youtube.com/watch?v=KxLxh-4Wgu4

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Identifying main parts surface condensers.	20%
2	Locate different areas of maintenance.	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. ……
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 11: Determination of thermal conductivity of metallic rod.

I Practical Significance

Conduction is dominant phenomenon of heat transfer in various applications. Value of thermal conductivity of different materials helps us to separate conductors from insulators. After doing this experiment students can determine experimentally thermal conductivity of any solid metallic rod.

II Relevant Program Outcomes (POs)

PO1 **- Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Mechanical engineering problems.
PO2 **- Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
PO8 **- Individual and team work:** Function effectively as a leader and team member in diverse / multidisciplinary teams.
PO9 **- Communication:** Communicate effectively in oral and written form.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.'**:

- Follow safety practices.
- Practice energy conservation.

IV Relevant Course Outcome(s)

- Use suitable modes of heat transfer.

V Practical Outcome

- Conduct a trial on conduction setup for a metallic rod and calculate thermal conductivity.

VI Minimum Theoretical Background

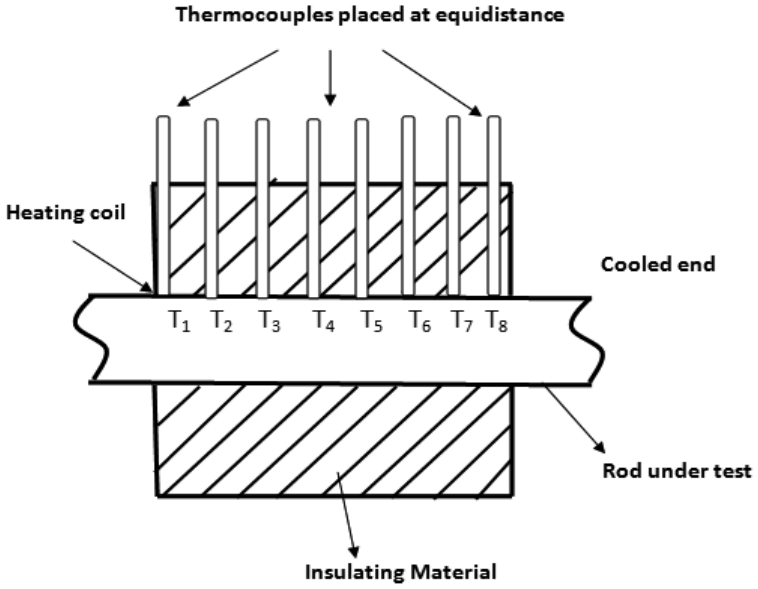
Fourier's law of conduction states that rate of heat transfer through a material is proportional to negative temperature gradient and to the area, at right angle to the gradient through which heat is flowing. Mathematically

$$Q \alpha - (dT / dx)$$

$$Q \alpha A$$

Steady state is condition when properties at a location do not change with respect to time.

VII Setup (Models) -



Experimental setup

VIII Resources Required

S.No	Name of Resource	Suggested Broad Specification	Quantity
1	Experimental set up for determination of thermal conductivity of a metallic rod.	Metallic rod of suitable length, Adequately insulated with heating arrangements at one end. Voltage regulator. Six thermocouples on metallic rod. Two thermocouples for water temperature. Arrangement for cooling other end of rod.	1 No.
2	Stop watch	----	1 No.
3	Measuring jar	1 litre	1 No.

IX Precautions to be Followed

- Do not touch heater end by bare hand.
- Use recommended voltage and amperage for heating rod.

X Procedure

1. Switch on Mains
2. Start cooling water supply and measure it. Note it.
3. Switch on the heater.
4. Adjust voltage regulator to get constant voltage and amperage. Note it.
5. Wait till steady state is reached.
6. Measure and note temperatures of thermocouples on given metallic rod. (T_1 to T_6)
7. Measure inlet & outlet temperatures of water. Note them. (T_7 & T_8)

XI Resources Used

S. No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		

XII Actual Procedure Followed

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XIII Precautions Followed

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XIV Observations and Calculations

m_w = Cooling water flow rate - ……. Kg/s

r = radius of given metallic rod = ….. m

Distance between two thermocouples = ….. m

S. No.	V	I	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8

(Note - Multiple reading are required to reach steady state. Use final reading for the calculations once steady state is achieved).

Calculation –

Q = - k A (dT/dx)

Also neglecting any heat loss through insulating material we can write

Q = V * I = ……..Watts (where V is voltage & I is current set)

A = cross sectional area of rod = $\pi * r^2$

dT/dx = Temperature gradient can be calculated by plotting a graph of temperature Vs distance at which thermocouples are positioned and then finding slope of curve obtained.

K = …… W/m K

XV Results

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XVI Interpretation of Results (Giving meaning to results)

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XVII Conclusions (Actions to be taken based on the interpretations.)

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XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Define thermal conductivity. State it's unit.
2. List thermal conductivity of commonly used engineering materials.
3. Discuss effects of chemical composition, state on thermal conductivity.
4. Discuss effect of temperature on thermal conductivity of metals and gases.
5. Discuss effect of pressure on thermal conductivity of liquids and gases.
6. If you want to calculate heat lost to insulating powder how will you calculate?

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XIX References / Suggestions for Further Reading

- http://nptel.ac.in/courses/103103032/module1/lec2/3.html
- https://www.youtube.com/watch?v=zFkJy_VocCk

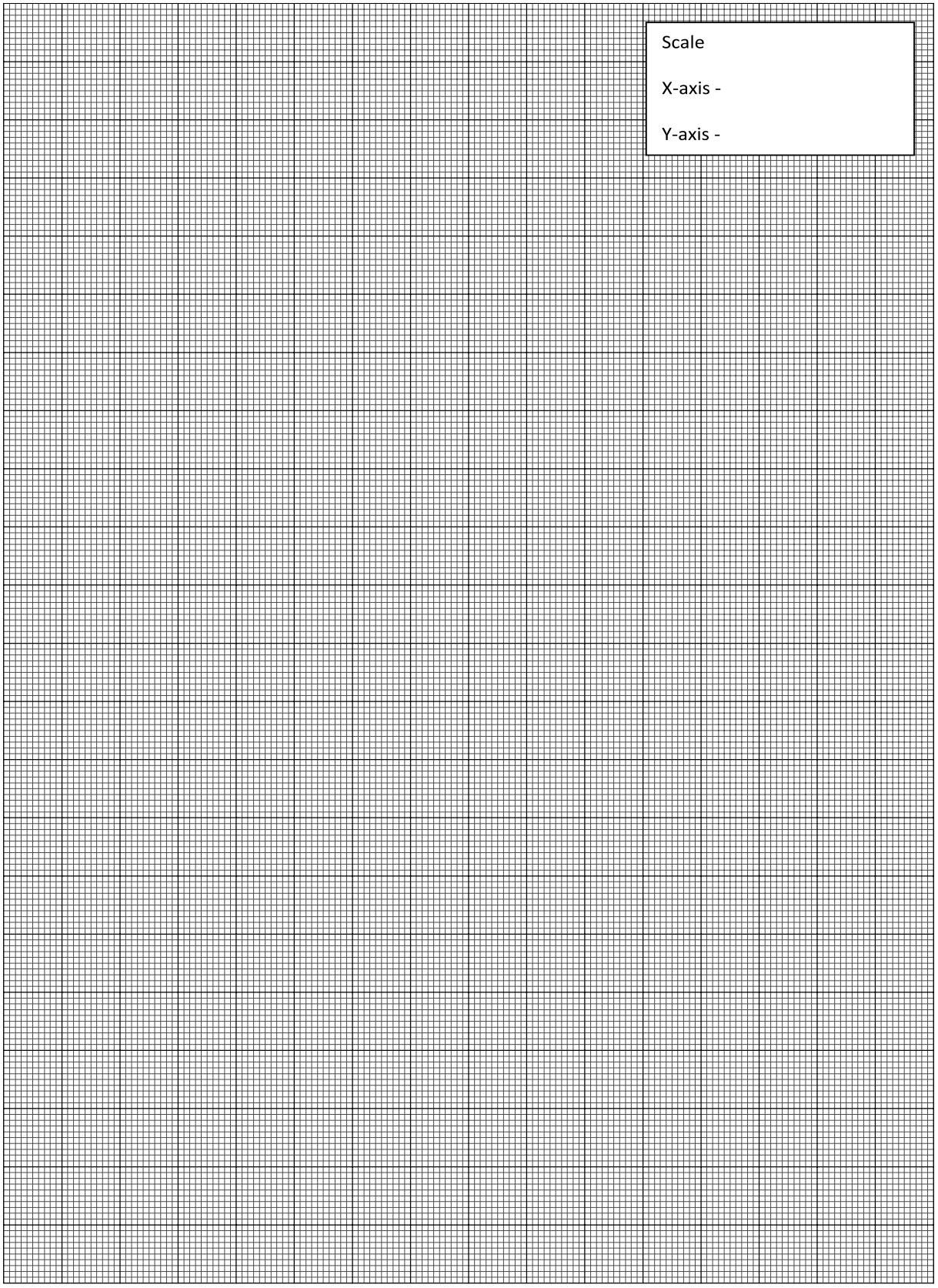
XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Performing the experiment satisfactorily	20%
2	Calculations done independently	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….……
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	


Scale
X-axis -
Y-axis -

Practical No. 12: Identification of heat exchangers

I Practical Significance

In mechanical engineering different devices use heat exchangers. They include IC engines, refrigerators, air-conditioners, power plants, sugar industry, textile industry and devices used in every sector of mechanical engineering. Selection of heat exchangers for different applications is one of the important tasks an engineer needs to perform.

II Relevant Program Outcomes (POs)

PO1 **- Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Mechanical engineering problems.
PO2 **- Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
PO8 **- Individual and team work:** Function effectively as a leader and team member in diverse / multidisciplinary teams.
PO9 **- Communication:** Communicate effectively in oral and written form.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.'**:

- Maintain tools and equipments.
- Practice energy conservation.

IV Relevant Course Outcome(s)

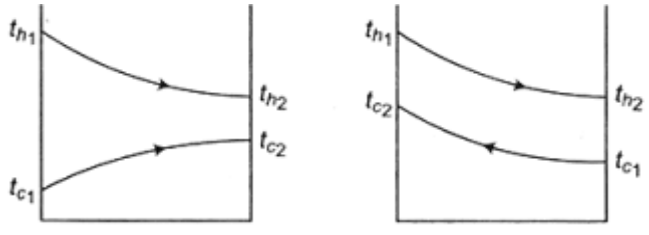
- Use suitable modes of heat transfer.

V Practical Outcome

- Identify different equipment in power engineering lab having heat exchangers and classify heat exchangers. Write construction and working any 03 of above heat exchangers.

VI Minimum Theoretical Background

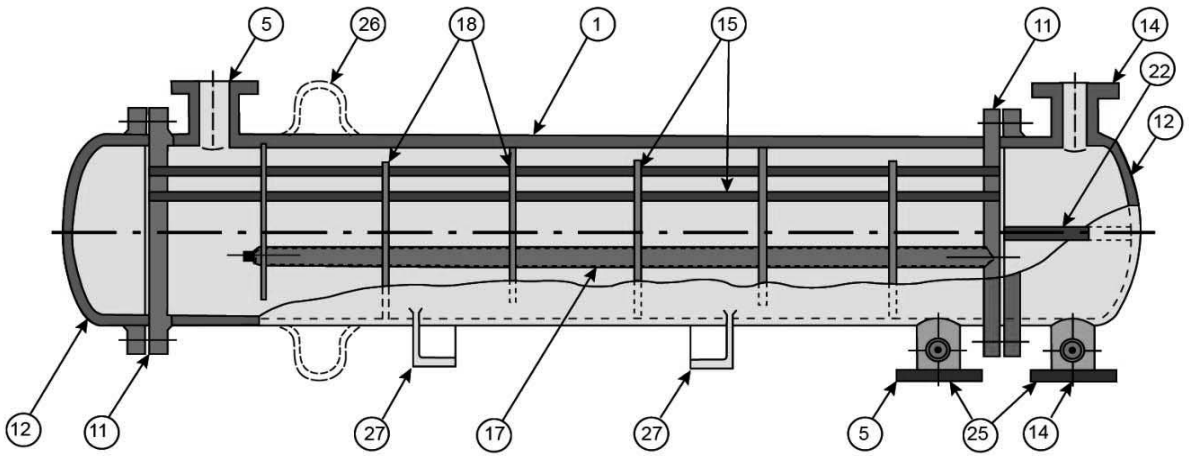
In design of heat exchangers Log Mean Temperature Difference is calculated for counter and parallel flow heat exchangers.



Parallel flow Counter flow

When hot and cold fluids flow in same direction it is called as parallel flow heat exchangers. When hot and cold fluid flows in opposite direction it is known as counter flow heat exchanger. Throughout the length of heat exchanger the temperature difference changes. "Log Mean Temperature Difference" is equivalent temperature difference which is constant throughout. It gives constant average rate of heat transfer.

VII Setup (Models) -



Shell & tube heat exchanger

VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
	Different heat exchangers available in laboratory.	Suitable size with temperature sensors for measuring hot and cold fluid temperatures.	2 No.

IX Precautions to be Followed

- Do not try & operate other systems of test rig.
- Protect your body parts from moving parts like coupling, belt etc.

X Procedure

1. Start the identified test rig (say IC engine test rig).
2. Locate heat exchangers in this test rig.
3. Run it for few minutes till it stabilizes.
4. Measure temperature of hot and cold fluids at inlets and outlets.
5. Adjust voltage regulator to get constant voltage and amperage. Note it.
6. Repeat it for atleast one another test rig (say refrigeration test rig.)

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XI Resources Used

S. No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		

XII Actual Procedure Followed

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XIII Precautions Followed

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XIV Observations and Calculations

Name of test rig	Name of heat exchanger	Type of heat exchanger	Hot fluid in temperature Th_i	Hot fluid out temperature Th_o	Cold fluid in temperature Tc_i	Cold fluid out temperature Tc_o
		Parallel or counter flow				

Calculation –

For parallel flow heat exchanger

$\theta i = th_i - tc_i$ = ……..= …..

$\theta o = th_o - tc_o$ = ……= …..

For counter flow heat exchanger

$\theta i = th_i - tc_o$ = …… = …..

$\theta o = th_o - tc_i$ = …… = …..

In both cases LMTD is calculated as

$LMTD = (\theta_i - \theta_o) / (\ln (\theta_i / \theta_o)$ = ……. For parallel flow

$LMTD = (\theta_i - \theta_o) / (\ln (\theta_i / \theta_o)$ = ……. For counter flow

XV Results

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XVI Interpretation of Results (Giving meaning to results)

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XVII Conclusions (Actions to be taken based on the interpretations.)

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XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Define heat capacity of hot and cold fluids.
2. State meaning of all terms involved in $\dot{Q} = U A \theta_m$
3. Elaborate concept of overall heat transfer coefficient.
4. State assumptions used in deriving formula for calculating LMTD.
5. Comment on *fouling* in heat exchangers.
6. Under which conditions you will select parallel flow and counter flow heat exchangers?
7. Can LMTD be applied in multi pass heat exchangers? If not what changes are required in LMTD?.

(Space for Answer)

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XIX References / Suggestions for Further Reading

- http://www.mesubjects.net/heat-exchangers-3-derivation-of-lmtd/
- https://www.youtube.com/watch?v=bMDOPlfCG0I
- https://www.youtube.com/watch?v=JqpYQG28TVc

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Performing the experiment	20%
2	Calculations	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(10)**	**Total (20)**	

Practical No. 13: Use of energy balance equation across heat exchanger.

I Practical Significance

Use of energy balance equation can be made to find unknown parameters in heat exchangers provided other parameters of hot and cold fluids are known. During this heat loss to surrounding is neglected. This experiment will be useful in design of heat exchangers.

II Relevant Program Outcomes (POs)

PO2 **- Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
PO3 **- Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.
PO8 **- Individual and team work:** Function effectively as a leader and team member in diverse / multidisciplinary teams.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.**':

- Measure different parameters on heat exchanger.
- Calculate mass flow rate of a fluid**.**

IV Relevant Course Outcome(s)

- Use relevant steam boilers.

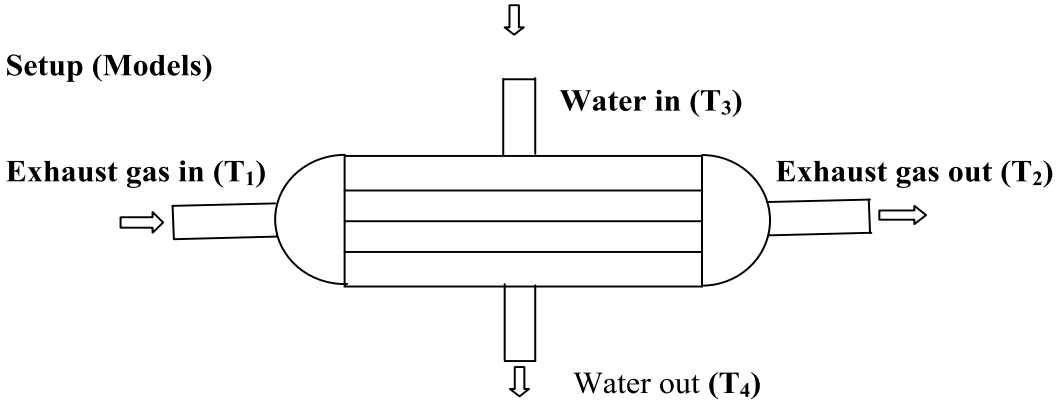
V Practical Outcome

- Conduct trial to determine mass flow rate of one fluid using energy balance equation in heat exchanger.

VI Minimum Theoretical Background

In heat exchanger energy is exchanged between hot and cold fluids. The heat to be exchanged is called as heat duty. As mass flow rate of fluid increases heat exchange also increases.

VII Setup (Models)



Heat Exchanger set up

VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
	Calorimeter of IC Engine test rig or suitable heat exchanger test rig	Suitable size	1 each
	Stopwatch & measuring jar	Suitable size	1 each

IX Precautions to be Followed

- Use safety shoes.
- Do not touch hot water lines.

X Procedure

1. Start Engine and run it at some constant load. Engine shall have calorimeter in the path of exhaust gases.
2. At same time open water flow to calorimeter.
3. After few minutes, measure temperatures of hot (gases) and cold fluid (water).
4. Measure flow rate of water using stop watch and measuring jar.
5. Perform calculations.

XI Resources Used

S. No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		

XII Actual Procedure Followed

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XIII Precautions Followed

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XIV Observations and Calculations

S. No.	T_1 (Gas in)	T_2 (Gas out)	T_3 (Water in)	T_4 (water out)	m_w (Mass flow rate of water
1					
2					
3					

Considering no heat loss from gases to surrounding write energy equation

$m_g * Cp_g * (T_1 - T_2) = m_w * Cp_w * (T_4 - T_3)$

m_g = Mass flow rate of gases to be calculated = ……kg/s

Cp_g = Specific heat for gases = ……. kJ/kg K

M_w = Mass flow rate of water = ……kg/s

Cp_g = Specific heat for water = ……. kJ/kg K

m_g = ……. kg/s

XV Results

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XVI Interpretation of Results (Giving meaning to results)

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XVII Conclusions (Actions to be taken based on the interpretations.)

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XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. List fouling coefficients of different fluids.
2. State guidelines for selecting fluids for tube side and shell side on priority side.
3. List dimensions of heat exchanger you have used for the experiment like tube OD, tube thickness, tube length, tube passes, shell diameter.
4. Define LMTD for parallel flow and counter flow heat exchangers.
5. Explain overall heat transfer coefficient.

(Space for Answer)

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XIX References / Suggestions for Further Reading

- http://nptel.ac.in/courses/103103027/pdf/mod1.pdf
- http://www.barriquand.com/en/news/how-to-design-heat-exchanger
- http://www.brighthubengineering.com/hvac/59900-fundamentals-of-heat-exchanger-theory-and-design/

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Performing experiment satisfactorily	20%
2	Calculations involved in energy balance	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 14: Determination of convective heat transfer coefficient (Forced convection)

I Practical Significance

Convection is dominant phenomenon of heat transfer. Many applications in engineering like cooling in IC engines and gas turbine blades, heat exchangers like boilers, condensers, evaporators etc., computers, electronic components use principle of convective heat transfer. Convection is dominant process in liquid and gases.

II Relevant Program Outcomes (POs)

PO1 **- Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Mechanical engineering problems.
PO2 **- Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
PO8 **- Individual and team work:** Function effectively as a leader and team member in diverse / multidisciplinary teams.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.**':

- Follow safety practices.
- Practice energy conservation.

IV Relevant Course Outcome(s)

- Use suitable modes of heat transfer.

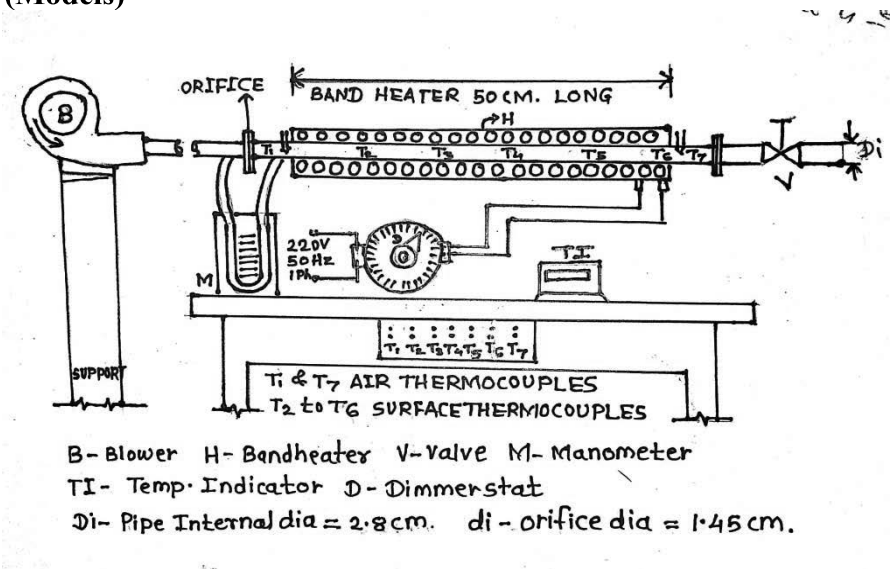
V Practical Outcome

- To determine convective heat transfer coefficient for the given fluid.

VI Minimum Theoretical Background

Convection is governed by Newton's law of cooling. It is transfer of heat between object and environment. Free, or natural, convection occurs when bulk fluid motions (streams and currents) are caused by buoyancy forces that result from density variations due to variations of temperature in the fluid. Forced convection is a term used when the streams and currents in the fluid are induced by external means—such as fans, stirrers, and pumps—creating an artificially induced convection current.

VII Setup (Models) -



Experimental setup

VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Experimental set up for determination of convective heat transfer coefficient (forced convection)	Electrical heater with dimmer stat (230 V & 2 A) for heating a pipe wall (length 0.5 m, ID – 28mm) and arrangement to force air using a blower. Temperature indicator unit with sensors at required places. Orifice meter to measure flow rate of air.	1 No.
2			
3			

IX Precautions to be Followed

- Do not touch heater end by bare hand.
- Use recommended voltage and amperage for heating rod.

X Procedure

1. Start the blower
2. Adjust mass flow rate of air with help of reading on U tube manometer
3. Ensure turbulent flow.
4. Adjust heater input
5. After steady state is reached, record all observations as per observation table.
6. Increase flow rate and again determine value of convective heat transfer coefficient

XI Resources Used

S. No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		

XII Actual Procedure Followed

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XIII Precautions Followed

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XIV Observations and Calculations

Di = Inside diameter of test section = …… m
L = Test section length = ……m
r_0 = radius of orifice = ……. m
A = Test section surface area = π * Di * L = …….m^2

Ts = Average temperature of surface of test section = $(T_2 + T_3 + T_4 + T_5 + T_6) / 5$
= …… …….K

Ta = $(T_1 + T_7)/ 2$
= ……. K

dT = (Ts – Ta) = …… K

Manometer reading = $h_w = h_1 – h_2$ = …… m

S. No.	V voltage	I current	T_1	T_2	T_3	T_4	T_5	T_6	T_7	h_1	h_2

(Note - Multiple reading are required to reach steady state. Use final reading for the calculations once steady state is achieved).

Calculation –
To find convective heat transfer coefficient……
$Q = h A (dT)$

$h = Q / A (dT)$

= …….. W/m^2K

To find Q…….

$Q = m_a * C_{pa} * (T_7 – T_1)$ = ……..…. W

Take for air C_{pa} =1.005 kJ/kg K

To find m_a ……..

$h_a Q_a = h_w Q_w$

h_a = …….. m

A_o = Area of orifice = πr_o^2 = ……..m^2

$V_a = C_d A_o \sqrt{(2gh_a)}$ = …… m^3/s

$m_a = Q_a * V_a$ = ……..kg/s

XV Results

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XVI Interpretation of Results (Giving meaning to results)

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XVII Conclusions (Actions to be taken based on the interpretations.)

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XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Define convective heat transfer coefficient. State it's unit.
2. List values of convective heat transfer coefficient for typical fluid flow applications.
3. Define Reynolds number, prandtl number.
4. State values of Reynolds number for different flow conditions of air.

5. Differentiate free convection and forced convection.
6. List applications for free and forced convection.
7. If flow rate of air increases what will be effect on heat transfer coefficient?

(Space for Answer)

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XIX References / Suggestions for Further Reading

- https://www.engineeringtoolbox.com/convective-heat-transfer-d_430.html
- http://nptel.ac.in/courses/103103032/10

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Performing the experiment satisfactorily	20%
2	Calculations done independently	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..…..
2. ……
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 15: Verification of Stefan Boltzmann law of radiation.

I Practical Significance

Experiment is used to verify value of Stefan Boltzmann constant. The law is widely used law of radiation. This law is useful in calculating the energy transferred by radiation from emitting surface to receiving surface such as heat transferred by solar radiation, radiation heat from furnace walls, induction heating coils etc.

II Relevant Program Outcomes (POs)

PO2 **- Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
PO3 **- Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.
PO8 **- Individual and team work:** Function effectively as a leader and team member in diverse / multidisciplinary teams.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.'**:

- Apply Stefan Boltzmann law to given situations.
- Calculate heat transfer by radiation.

IV Relevant Course Outcome(s)

- Use suitable modes of heat transfer

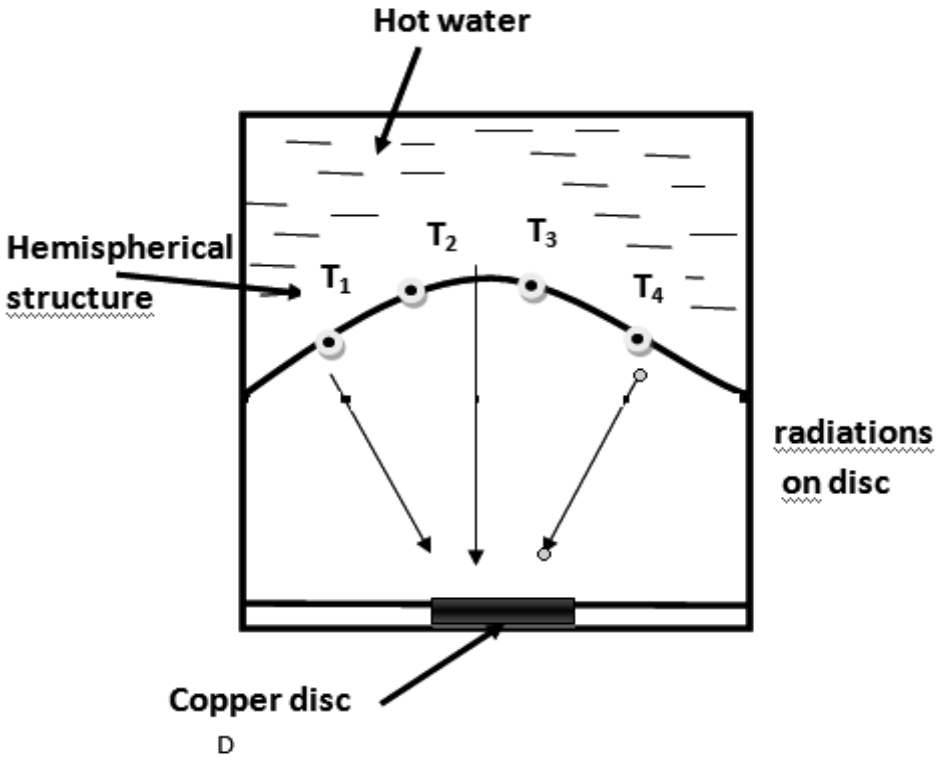
V Practical Outcome

- Verify of Stefan-Boltzmann constant for radiation.

VI Minimum Theoretical Background

Stefan-Boltzmann law, statement that the total radiant heat energy emitted from a surface is proportional to the fourth power of its absolute temperature. Black body is a body having absorptivity and emissivity both are 1. The value of Stefan Boltzmann constant is $5.67 * 10^{-8}$ $W/m^2 K^4$

VII Setup (Models) -



Experimental setup for Stefan Boltzmann law

VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Stefan-Boltzmann apparatus.	Hemispherical enclosure with water jacket, base plate, Sleeve, test disc, thermocouples.	1 each
2			
3			
4			

IX Precautions to be Followed

- Use safety shoes.
- Do not touch heated surface with bare hand.

X Procedure

1. The water in the tank is heated by immersion heater up to a temperature of about 90 ^{o}C.
2. The disc D is removed before pouring the hot water in the jacket.
3. The hot water is poured in the water jacket.
4. The hemispherical enclosure will come to some uniform temperature T in short time after filling the hot water in jacket.
5. The enclosure will soon come to thermal equilibrium conditions.
6. The disc D is now inserted back at a time when its temperature is say T_5 (to be sensed by separate thermocouple).
7. As soon as disc is inserted timer is started and temperature of disc is recorded after every 5 seconds.

XI Resources Used

S. No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		

XII Actual Procedure Followed

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XIII Precautions Followed

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XIV Observations and Calculations

Calculate average temperature of hemisphere using four thermocouples located on it.

Themocouple	T_1 (K)	T_2 (K)	T_3 (K)	T_4 (K)
Temperature ^oC				

Average temperature of hemisphere = T = (T_1 + T_2 + T_3 + T_4) /4

1. Temperature to which water is heated = …… ^oC
2. Mass of disc (m_D) = ……. kg
3. Radius of disc = …….. m
4. Specific heat of disc material ($Cp_{D)}$ = 0.4186 KJ/kg ^oC (for copper)

Time, sec	0	5	10	15	20	25	30
Temperature, ^oC							

Plot a graph of temperature of disc taking on y axis and time on x axis.

Find slope of graph at $(dT/dt)_{t=0}$ = …….. K/sec

Now heat radiated by hemisphere is equal to heat absorbed by copper disc.

$\sigma * A_D * (T^4 - T_D^4) = m * Cp_D * (dT/dt)_{t=0}$

T_D = Temperature of disc at the instant when it is inserted.

A_D = Area of disc = …….m^2

$\sigma = (m_D * Cp_D * (dT/dt)_{t=0}) / (A_D * (T^4 - T_D^4))$ = …….

σ = ……W/m^2K^4

XV Results

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XVI Interpretation of Results (Giving meaning to results)

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XVII Conclusions (Actions to be taken based on the interpretations.)

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XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Define radiation heat transfer.
2. Give practical examples where radiation heat transfer is dominant.
3. Define black body and emissivity.
4. State the applications where Stefan Boltzmann constant can be used.

(Space for Answer)

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XIX References / Suggestions for Further Reading

- https://www.youtube.com/watch?v=MUAc_pAMNig
- http://nptel.ac.in/courses/112108149/pdf/M9/Student_Slides_M9.pdf

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(40%)**
1	Measuring required parameters.	20%
2	Calculating Stefan Boltzmann constant.	20%
Product Related (15 Marks)		**(60%)**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..……..
2. ……..…….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

List Of Laboratory Manuals Developed by MSBTE

First Semester:

1	Fundamentals of ICT	22001
2	English	22101
3	English Work Book	22101
4	Basic Science (Chemistry)	22102
5	Basic Science (Physics)	22102

Second Semester:

1	Bussiness Communication Using Computers	22009
2	Computer Peripherals & Hardware Maintenace	22013
3	Web Page Design with HTML	22014
4	Applied Science (Chemistry)	22202
5	Applied Science (Physics)	22202
6	Applied Machines	22203
7	Basic Surveying	22205
8	Applied Science (Chemistry)	22211
9	Applied Science (Physics)	22211
10	Fundamental of Electrical Engineering	22212
11	Elements of Electronics	22213
12	Elements of Electrical Engineering	22215
13	Basic Electronics	22216
14	'C' programming Language	22218
15	Basic Electronics	22225
16	Programming in "C"	22226
17	Fundamentals of Chemical Engineering	22231

Third Semester:

1	Applied Multimedia Techniques	22024
2	Advanced Serveying	22301
3	Highway Engineering	22302
4	Mechanics of Structures	22303
5	Building Construction	22304
6	Concrete Technology	22305
7	Strength Of Materials	22306
8	Automobile Engines	22308
9	Automobile Transmission System	22309
10	Mechanical Operations	22313
11	Technology Of Inorganic Chemicals	22314
12	Object Oriented Programming Using C++	22316
13	Data Structure Using 'C'	22317
14	Computer Graphics	22318
15	Database Management System	22319
16	Digital Techniques	22320
17	Principles Of Database	22321
18	Digital Techniques & Microprocessor	22323
19	Electrical Circuits	22324
20	Electrical & Electronic Measurment	22325
21	Fundamental Of Power Electronics	22326
22	Electrical Materials & Wiring Practice	22328
23	Applied Electronics	22329
24	Electrical Circuits & Networks	22330
25	Electronic Measurments & Instrumentation	22333
26	Principles Of Electronics Communication	22334
27	Thermal Engineering	22337
28	Engineering Matrology	22342
29	Mechanical Engineering Materials	22343
30	Theory Of Machines	22344

Fourth Semester:

1	Hydraulics	22401
2	Geo Technical Engineering	22404
3	Chemical Process Instrumentation & Control	22407
4	Fluid Flow Operation	22409
5	Technology Of Organic Chemicals	22410
6	Java Programming	22412
7	GUI Application Development Using VB.net	22034
8	Microprocessor	22415
9	Database Managment	22416
10	Electric Motors And Transformers	22418
11	Industrial Measurements	22420
12	Digital Electronics And Microcontroller Applications	22421
13	Linear Integrated Circuits	22423
14	Microcontroller & Applications	22426
15	Basic Power Electronics	22427
16	Digital Communication Systems	22428
17	Mechanical Engineering Measurments	22443
18	Fluid Mechanics and Machinery	22445
19	Fundamentals Of Mechatronics	22048

Fifth Semester:

1	Design of Steel and RCC Structures	22502
2	Public Health Engineering	22504
3	Heat Transfer Operation	22510
4	Environmental Technology	22511
5	Operating Systems	22516
6	Advanced Java Programming	22517
7	Software Testing	22518
8	Control Systems and PLC's	22531
9	Embedded Systems	22532
10	Mobile and Wireless Communication	22533
11	Industrial Machines	22523
12	Switchgear and Protection	22524
13	Energy Conservation and Audit	22525
14	Power Engineering and Refrigeration	22562
15	Solid Modeling and Additive Manufacturing	22053
16	Guidelines & Assessment Manual for Micro Projects & Industrial Training	22057

Sixth Semester:

1	Solid Modeling	17063
2	Highway Engineering	17602
3	Contracts & Accounts	17603
4	Design of R.C.C. Structures	17604
5	Industrial Fluid Power	17608
6	Design of Machine Elements	17610
7	Automotive Electrical and Electronic Systems	17617
8	Vehicle Systems Maintenance	17618
9	Software Testing	17624
10	Advanced Java Programming	17625
11	Mobile Computing	17632
12	System Programing	17634
13	Testing & Maintenance of Electrical Equipments	17637
14	Power Electronics	17638
15	Illumination Engineering	17639
16	Power System Operation & Control	17643
17	Environmental Technology	17646
18	Mass Transfer Operation	17648
19	Advanced Communication System	17656
20	Mobile Communication	17657
21	Embedded System	17658
22	Process Control System	17663
23	Industrial Automation	17664
24	Industrial Drives	17667
25	Video Engineering	17668
26	Optical Fiber & Mobile Communication	17669
27	Therapeutic Equipment	17671
28	Intensive Care Equipment	17672
29	Medical Imaging Equipment	17673

Pharmacy Lab Manual

First Year:

1	Pharmaceutics - I	0805
2	Pharmaceutical Chemistry - I	0806
3	Pharmacognosy	0807
4	Biochemistry and Clinical Pathology	0808
5	Human Anatomy and Physiology	0809

Second Year:

1	Pharmaceutics - II	0811
2	Pharmaceutical Chemistry - II	0812
3	Pharmacology & Toxicology	0813
4	Hospital and Clinical Pharmacy	0816

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