LABORATORY MANUAL

Heat and Mass Transfer

(ME 508)

Department of Mechanical Engineering

Jorhat Engineering College

Jorhat – 785007 (Assam)

COLLEGE VISION AND MISSION

Vision:

To develop human resources for sustainable industrial and societal growth through excellence in technical education and research.

Mission:

1. To impart quality technical education at UG, PG and PhD levels through good academic support facilities.

2. To provide an environment conducive to innovation and creativity, group work and entrepreneurial leadership.

3. To develop a system for effective interactions among industries, academia, alumni and other stakeholders.

4. To provide a platform for need-based research with special focus on regional development.

DEPARTMENT VISION AND MISSION

Vision:

To emerge as a centre of excellence in mechanical engineering and maintain it through continuous effective teaching-learning process and need-based research.

Mission:

M1: To adopt effective teaching-learning processes to build students capacity and enhance their skills.

M2: To nurture the students to adapt to the changing needs in academic and industrial aspirations.

M3: To develop professionals to meet industrial and societal challenges.

M4: To motivate students for entrepreneurial ventures for nation-building.

Program Outcomes (POs):

Engineering graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Educational Objectives (PEOs):

The Programme Educational Objectives of Department of Mechanical Engineering are given below:

PEO1: Gain basic domain knowledge, expertise and self-confidence for employment, advanced studies, R&D, entrepreneurial ventures activities, and facing challenges in professional life.

PEO2: Develop, improve and maintain effective domain based systems, tools and techniques that socioeconomically feasible and acceptable and transfer those technologies/developments for improving quality of life.

PEO3: Demonstrate professionalism through effective communication skill, ethical and societal commitment, team spirit, leadership quality and get involved in life-long learning to realize career and organisational goal and participate in nation building.

Program Specific Outcomes (PSOs)

The programme specific outcomes of Department of Mechanical Engineering are given below:

PSO1: Capable to establish a career in Mechanical and interdisciplinary areas with the commitment to the society and the nation.

PSO2: Graduates will be armed with engineering principles, analysing tools and techniques and creative ideas to analyse, interpret and improve mechanical engineering systems.

Course Outcomes (COs)

At the end of the course, the student will be able to:

CO1	Apply Fourier's law to validate the theoretical over all heat transfer coefficient.
CO2	Apply Stefan-Boltzmann law of radiation and emissivity relation.
CO3	Determine thermal properties of material by applying 1-D steady state heat transfer equation.
CO4	Apply non-dimensional numbers to evaluate and validate heat transfer parameters.

Mapping of COs with POs:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2				1	1	1		1	2	2
CO2	3	2	1	1			1	1	1	1		1	1	1
CO3	3	2	1	1				1	1	1		1	1	1
CO4	3	2	2	2			1	1	1	1		1	1	2

STUDENT PROFILE	
NAME :	
ROLL NUMBER :	
SECTION :	
SEMESTER :	5th Semester
YEAR :	

PERFORMANCE RECORD		
EXP. NO.	**TITLE OF EXPERIMENT**	**REMARKS / GRADE**
1	Heat transfer through composite walls apparatus.	
2	Emissivity measurement apparatus.	
3	Thermal conductivity of insulating powder.	
4	Heat transfer in natural convection.	
5	Critical Heat Flux Apparatus.	
6	Heat Transfer through Lagged Pipe Apparatus.	

OFFICE USE	
Checked By :	
Overall Grade / Marks :	
Signature of Teacher :	

Experiment No. 1

TITLE: Heat transfer through composite walls apparatus.

OBJECTIVE:

To determine the overall heat transfer co-efficient for the composite wall and to compare the same with that calculated from the equations.

THEORY:

The heat flow through a composite wall is given by $q = U\ A\ \Delta T$

Where $U_0 =$ overall heat transfer co-efficient in (W/m^{2}C)

For a composite wall having three layers, U_0 can be found out from the following equation

$$U_0 = \frac{1}{\frac{l_1}{k_1} + \frac{l_2}{k_2} + \frac{l_3}{k_3}}$$

Where l_1, l_2 and l_3 are the thickness of the three layers K_1, K_2 & K_3 are the thermal conductivities of the three layers.

DESCRIPTION OF THE APPARATUS:

The apparatus consists of three stabs made of mild steel, asbestos and brass having same thicknesses. The three stabs are clamped on both sides using bolts and nuts. On one side of the composite wall a heater is provided. The heater input can be varied using a dimmerstat Thermocouples are embedded at three different places in each section to find out the average temperature. On the outside of the wall cooling water jacket is provided which takes away the heat conducted through the slabs. The mass rate of flow of water and its raise in temperature can be determined.

SPECIFICATIONS:

Diameter of the composite wall	=	150 mm
Thickness of each slab	=	6 mm
Thermal conductivity of mild steel K_1	=	45 w/mk
Thermal conductivity of asbestos K_2	=	0.1662 w/mk
Thermal conductivity of brass K_3	=	100 w/mk

PROCEDURE:

1. Connect the equipment to power supply.
2. Adjust the power input to the required valve.
3. Allow sufficient time to attain steady state.
4. Note down all the temperatures by operating the knob.
5. Measure water flow rate and its raise in temperature.
6. Repeat the experiment for different heat input.

SPECIMEN CALCULATIONS:

(a) Heat rate, $Q = VI$ watt

(b) Mass flow rate of water, $m = \rho\, Q$ (kg/s)
(Where ρ is the density of water in kg/m^3 and Q is the flow rate in m^3/s)

(c) Heat taken by water, $Q_w = m\, C_{pw}\,(T9 - T10)$

(d) Mean temperature at hot end of the composite wall,

$$(i)\ T_b = \frac{(T1 + T2)}{2} \qquad (ii) T_c = \frac{(T7 - T8)}{2}$$

(e) Heat transfer area, $A = (\pi/4)D^2$, where D is the diameter of wall

(f) The experimental overall heat transfer co-efficient,

$$U_E = \frac{Q_w}{A(T_b - T_c)} \quad (W/m^2\,C)$$

Compare experimental overall heat transfer coefficient with theoretical overall heat transfer coefficient

OBSERVATION TABLE:

Time (min)	Heat Input			Temperature of Hot End (°C)		Temperature of Cold End (°C)		Water Inlet Temperature (°C)	Water Outlet Temperature (°C)	Water Flow Rate (ml/min)
	V (volt)	I (amp)	W (watt)	T1	T2	T7	T8	T10	T9	

CALCULATION:

RESULT TABLE:

Mass flow rate of water (kg/s)	Heat taken by water (Q_w)	Mean temperature at hot end of the composite wall		Heat Transfer Area (A)	Experimental overall heat transfer co-efficient	Theoretical overall heat transfer co-efficient	% variation
		T_b	T_c				

Exp. No. 1	**Title:** Heat transfer through composite walls apparatus.
Name of Student:	
Roll No.:	
Date of Experiment:	
Date of Submission:	
Signature of Teacher with Date of Check	**SEAL**

Experiment No. 2

TITLE: Emissivity measurement apparatus.

OBJECTIVE:

To determine the emissivity of a grey surface at different temperatures

THEORY:

According to Stefan – Boltzman law, the radiation energy emitted by a black body at an absolute temperature T is proportional to the fourth power of the absolute temperature.

$$Q = \sigma\, A\, T^4$$

Where, $\sigma =$ Stefan Boltzmann constant $= 5.6697 \times 10^{-8}\ W/(m^2K^4)$

Emissive Power:

The emissive power E_b of a black surface is defined as the energy emitted by the surface per unit time, per unit area.

Black Body:

A black body is one, which is capable of absorbing all the incident radiation. At the same time a black body is a perfect emitter.

Grey Body:

A grey body is one, which absorbs only a definite percentage of incident radiation.

Emissivity:

Emissivity of a surface is a measure of how it emits radiant energy in comparison with a black body at the same temperature, or emissivity of a surface is a ratio of emissive power of the surface to the emissive power of a perfect black body at the same temperature.

$$\varepsilon = \frac{E}{E_b}$$

Where,

$\varepsilon =$ Emissivity

$E =$ Emissive power of the gray body

$E_b =$ Emissive power of the perfect black body

DESCRIPTION OF THE APPARATUS:

The experimental set up consists of two circular plates of identical dimensions. One of the plates is made black by applying a thick layer of lamp black while the other plate whose emissivity is to be measured is non black. Heating coils are provided at the bottom of both plates. The plates are mounted on asbestos cement sheet and kept in an enclosure to provide undisturbed natural convection conditions. The heat input to the plate is having three thermocouples for temperature measurements. One thermocouple is kept in the chamber to read the ambient or chamber temperature.

SPECIFICATIONS:

Diameter of the plates = 150 mm

PROCEDURE:

1. Connect the two heaters to the electric mains
2. Operate the dimmerstat and give the power input to the both plates
3. Adjust same heat input to both surfaces say 50 V by rising cam switches for heater 1 and heater 2
4. When steady state is reached (say after about 30 minutes) note down the temperatures T I to T6 by rotating the temperature selection switch
5. Note down the chamber temperature
6. Repeat the experiments for different voltage input.

OBSERVATION TABLE:

Time (min)	V (volt)	A (amp)	W (watt)	Temperature of Black Surface			Temperature of Grey Surface			Ambient Temperature
				T1	T2	T3	T4	T5	T6	T7

CALCULATION:

RESULT TABLE:

Time (min)	Temperature of the Black surface (K) $T_B = \frac{(T1 + T2 + T3)}{3}$	Temperature of the Grey surface (K) $T_E = \frac{(T4 + T5 + T6)}{3}$	Heat input $W = V \times I$	Emissivity $\varepsilon = \frac{(T_E{}^4 - T_7{}^4)}{(T_B{}^4 - T_7{}^4)}$

Exp. No. 2	**Title:** Emissivity measurement apparatus.
Name of Student:	
Roll No.:	
Date of Experiment:	
Date of Submission:	
Signature of Teacher with Date of Check	**SEAL**

Experiment No. 3

TITLE: Thermal conductivity of insulating powder.

OBJECTIVE:

To determine the thermal conductivity of insulating powder at various heat inputs.

THEORY:

Fourier Law of Heat Conduction states that "rate of heat flow through a surface is directly proportional to the area normal to the surface and the temperature gradient across the surface."

$$\frac{q}{A} \propto \frac{dT}{dX}$$

$$q = -KA\frac{dT}{dX}$$

Negative sign indicates that the heat flows from higher temperature to the lower temperature. K is called the thermal conductivity.

THERMAL CONDUCTIVITY:

Thermal conductivity can be defined as the amount of heat that can flow per unit time across unit cross sectional area when the temperature gradient is unity. The unit of thermal conductivity is W/m-K. Materials having higher thermal conductivity are called conductors, while those having lower thermal conductivity are called insulators. Examples for good conductors include all metals. While asbestos, magnesia, glass wool etc, are some example of insulators.

The radial heat conduction for single hollow sphere transferring heat from inside to outside is given by:

$$q = \frac{4\pi r_i r_0 (T_1 - T_0)}{(r_0 - r_i)}$$

Where,

q = Rate of heat transfer in watts

K = Thermal conductivity, w/m-K

r_i = Radius of inner sphere in meters

r_0 = Radius of outer sphere in meters

T_i = Temperature of the inner sphere

T_0 = Temperature of the outer sphere

DESCRIPTION:

The apparatus consists of two concentric copper spheres. Heating coil is provided in the inner sphere. The space between the inner and outer spheres are filled by the insulating powder whose thermal conductivity is to be determined. The power supply to the heating coil is adjusted by using variac. Chromel-Alumel thermocouples are used to record the temperatures. Thermocouples 1 to 6 are embedded on the surface of inner sphere and 7 to 12 are embedded on the outer shell surface.

SPECIFICATION:

Radius of inner sphere	= 100 mm
Radius of outer sphere	= 200 mm
Voltmeter	= 0-300 V
Ammeter	= 0-5 amp
Variac	= 2 Amps
Temperature Indicator	= 0 – 300 ^{0} C

PRECAUTIONS: Keep variac to zero volt position before switching “on” the unit and after the experiment.

PROCEDURE:

1. Connect the unit to an AC source 240 V, 5 Amp and switch on the MCB.
2. Operate the variac slowly to increase the heat input to the heater and adjust the voltage to any desire voltage (do not exceed 150 V)
3. Maintain the same heat input throughout the experiment until the temperatures reaches a steady state.
4. Note down the following readings provided to the observation table.

OBSERVATION TABLE:

Heat Input				Inner Surface Temperature (°C)						Outer Surface Temperature (°C)					
Time (min)	V (volt)	A (Amp)	Watt	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12

CALCULATION:

RESULT TABLE:

Heat input rate Q = VI (watt)	Inner surface Average temperature (℃) T_i $= \frac{T1+T2+T3+T4+T5+T6}{6}$	Outer surface Average temperature (℃) T_0 $= \frac{T7+T8+T9+T10+T11+T12}{6}$	Thermal Conductivity of the powder $K = \frac{q(r_0 - r_i)}{4r_0 r_i (T_i - T_0)}$ $(W/m\ K)$

Exp. No. 3	**Title:** Thermal conductivity of insulating powder.
Name of Student:	
Roll No.:	
Date of Experiment:	
Date of Submission:	
Signature of Teacher with Date of Check	**SEAL**

Experiment No. 4

Title: Heat transfer in natural convection.

OBJECTIVE:

1. To determine the convective heat transfer co-efficient for heated vertical cylinder losing heat to the ambient by free or natural convection

2. To find the theoretical convective heat transfer coefficient and to compare with the experimental value.

THEORY:

Convection heat transfer occurs by the movement of fluid particles. If the motion of fluid particles occurs by the variation of density of the fluid due to temperature difference, then the heat transfer process is called free or natural convection

The rate of heat transfer in convection is given by the Newton's law of cooling i.e.

$$Q = h\,A\,\Delta T$$

Where,

$Q =$	Heat transfer in w
$A =$	Area of the tube.
$\Delta T =$	Change in temperature.
$H =$	Convective or film heat transfer coefficient, h depends upon the fluid properties, type of flow and geometry of the surface.

DIMENSIONLESS NUMBERS:

Nusselt Number:

$$Nu = \frac{hL}{K} = \frac{L/K}{1/h}$$

$$Nu = \frac{\text{Conductive resistance}}{\text{Convective resistance}} = \frac{\text{Heat transfer by convection}}{\text{Heat transfer by conduction}}$$

A larger value of Nu implies enhanced heat transfer by convection.

Prandtl Number:

$$Pr = \frac{\nu}{\alpha} = \frac{\text{Viscous Diffusion Rate}}{\text{Thermal Diffusion Rate}} = \frac{\mu C_p}{K}$$

This number represents the relative importance of momentum and energy transfer by diffusion process.

Grashof Number:

$$GR = \frac{L^3 \beta g \Delta T}{\nu^2} = \frac{(\text{Inertia force})(\text{Buoyant force})}{(\text{Viscous force})^2}$$

Grashof number has an important role in free convection problems.

From dimensional analysis as per the Buckingham p1 theorem, a general relationship between the above dimensionless numbers has been developed as given below:

$$\boldsymbol{Nu = C(GrPr)^m} \quad , \quad \text{where } m \text{ and } C \text{ are constants}$$

Experimental convective heat transfer coefficient,

$$h_{exp} = q/A(T_s - T_\alpha)$$

Where,

$q =$ Heat Input

$T_s =$ Surface Temperature

$T_\alpha =$ Ambient Temperature

$A = \pi dL =$ Surface area of the pipe

Theoretical convective heat transfer coefficient,

$$h_{theo} = (NuK)/d$$

$$Nu = 0.59(GrPr)^{0.25}$$

$$GrPr = \frac{L^3 \beta g \Delta T Pr}{\nu^2}$$

DESCRIPTION OF THE APPARATUS:

The apparatus consists of a vertical stainless steel tube enclosed in a rectangular duct; front side of the duct is made of transparent section to facilitate visual observation. An electrical heating element embedded in a copper tube acts as the heat source. The surface temperature is measured at different heights using thermocouples. The surface of the tube is polished to minimize radiation losses. A voltmeter and an ammeter enable the determination of wattage dissipated by the heater. The chamber temperature can also be measured.

SPECIFICATION:

Diameter of the Tube	=	45 mm
Length of the Tube	=	500 mm

PROCEDURE:

1. Connect the equipment to power supply. Set the voltmeter reading to some value say 50 V by using the dimmerstat and maintain it constant.
2. Allow sufficient time for obtaining steady state conditions.
3. After Steady state is reached note down the temperature T1 to T7 from the indicator by operating the temperature selector switch.
4. Note down the Ambient temperature
5. Repeat the experiment for different heat inputs

OBSERVATION TABLE:

Time (min)	V (volt)	I (amp)	W (watt)	Temperatures on the surface of the pipe							T_{avg} T_s	Ambient temperature T_α
				T1	T2	T3	T4	T5	T6	T7		

CALCULATION:

RESULT TABLE:

Film temp $T_f = (T_s + T_\alpha)/2$	Properties of air (from tables) at T_f				GrPr	Nu	h_{theo}	h_{exp}	% variation
	ν (m^2/sec)	Pr	K (W/mK)	$\beta = 1/T_f$					

Exp. No. 4	**Title:** Heat transfer in natural convection.
Name of Student:	
Roll No.:	
Date of Experiment:	
Date of Submission:	

Signature of Teacher with Date of Check **SEAL**

Experiment No. 5

TITLE: Critical Heat Flux Apparatus.

OBJECTIVE:

To study the formation of bubbles under pool boiling process and calculate the value of critical heat flux.

THEORY:

Boiling Heat Transfer Phenomena:

In general boiling is a convection process involving a change in phase from liquid to vapour. Boiling may occur when a liquid is in contact with a surface maintained at a temperature higher than the saturation temperature of the liquid.

Pool Boiling:

If heat is added to a liquid from a submerged solid surface, the boiling process is referred to as pool boiling. In this process the vapour produced may form bubbles, which grows and subsequently detach them from the surface, rising to the free surface due to buoyancy effects.

Regimes of Pool Boiling (for Water):

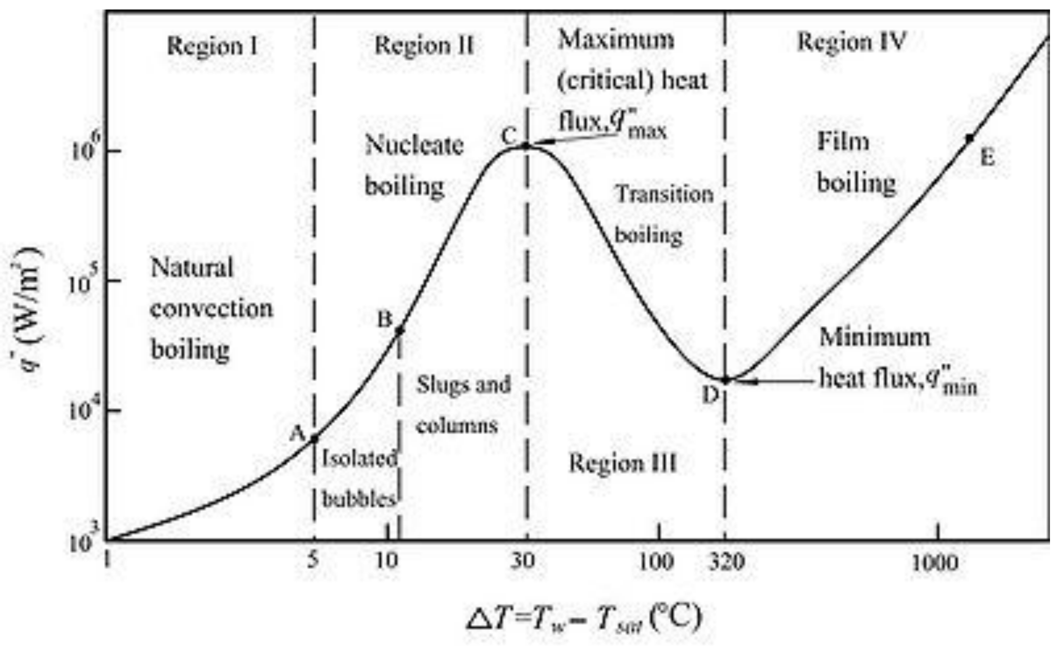

Figure 5.1: Regimes of Pool Boiling

1. **Free convection zone:** In region I, called the free convection zone, the excess temperature T is very small considering here the liquid near the surface is superheated slightly, the convection currents circulate the liquid and evaporation takes place at liquid surface
2. **Nucleate Boiling:** This exists in regions II. As the excess temperature T is created, bubbles begin to form on the surface of the wire at certain localized spots. The bubbles condense in the liquid without reaching the liquid surface. Region II represents the beginning of nucleate boiling. With the increase in excess temperature, bubbles are formed more rapidly and rise to the surface of the liquid resulting in rapid evaporation. The maximum heat flux, known as critical heat flux occurs at point C& is about 1 MW/m^2.
3. **Transition Boiling:** In this region the heat flux decreases. This is because a large fraction of the heater surface is covered by a vapour film, which acts as an insulation due to the low thermal conductivity of the vapour relative to that of the liquid. In transition boiling regime, both nucleate and film boiling partially occur. Nucleate boiling t point C is completely replaced by film boiling at point D.
4. **Film Boiling Region:** In this region the heater surface is completely covered by a continuous stable vapour film. The heat transfer rate increases with increasing excess temperature as a result of heat transfer from the heated surface to the liquid through the vapour film by radiation, which becomes significant at high temperatures.

The stable boiling phenomenon can be observed when a drop of water falls on a red hot stove. The drop does not evaporate immediately but dances a few times on the stove. This is due to the formation of a stable steam film at the interface between the hot surface and the liquid droplet. This observation was first made by J. C. Leidenfrost and thus the point D, where the heat flux reaches a minimum is called the Leidenfrost point in his honour.

SPECIFICATONS:

Length of the nichrome wire	=	40 mm
Diameter of the nichrome wire	=	0.25 mm (33 gauge)

PROCEDURE:

1. Connect the nichrome test wire to heat terminals & place it in the container having distilled water.
2. Switch on the main heater and heat the water to the desired temperature (70^0C) and then switch off the main heater.
3. Now switch on the test heater. Gradually increase the voltage across the test heater by using the Variac. Continue this till the wire breaks down.
4. Calculate the value of the critical heat flux using the value of current and voltage obtained at burnout.

OBSERVATION TABLE:

Sl. No.	Voltage (V)	Current (I)	Heat input $q = V \times I$	Value of Critical Heat Flux (MW/m^2)

CALCULATION:

Exp. No. 5	**Title:** Critical Heat Flux Apparatus.
Name of Student:	
Roll No.:	
Date of Experiment:	
Date of Submission:	

Signature of Teacher with Date of Check **SEAL**

Experiment No. 6

TITLE: Heat Transfer through Lagged Pipe Apparatus.

OBJECTIVE:

Plot the radial temperature distribution in the composite cylinder and determine the thermal conductivity of the pipe insulation.

THEORY:

Consider one dimensional radial heat flow through a hollow cylinder, under steady state conditions:

$$q = \frac{2\pi KL\ (T1 - T2)}{\ln\frac{r2}{r1}}$$

Where,

T1 & T2	=	Inner and Outer Wall Temperature.
r1 and r2	=	The Inner and Outer Radii of the Pipe.
K	=	Thermal conductivity of the material.

DESCRIPTION OF THE APPARATUS:

The apparatus consists of a metal pipe with two layers of insulation. An electric heating coil wound on a silica rod is placed at the centre. The ends are thickly insulated to prevent heat loss so that, heat can flow only in a radial direction. Three thermocouples each are placed at different radii to measure the temperature distribution within the cylinder.

SPECIFICATONS:

1.	Location of thermocouples 1,2,3 at radius	=	30mm
2.	Location of thermocouples 4,5,6 at radius	=	52mm
3.	Location of thermocouples 7,8,9 at radius	=	55mm
4.	Length of Pipe	=	500mm

PROCEDURE:

1. Connect the equipment to a 230 V, 5A, 50 Hz electrical source.
2. Turn the dimmerstat knob clockwise and fix the heat input to a desired wattage.
3. Allow the equipment to stabilize and attain steady state.
4. Turn the thermocouple selector switch knob clockwise and note down temperatures T1 to T9.
5. Repeat the experiment for different heat inputs.

OBSERVATION TABLE:

Sl. No.	Heat Input (Watt)			Temp. at radius R1 (^oC)			Avg. (^oC)	Temp. at radius R2 (^oC)			Avg. (^oC)	Temp. at radius R3 (^oC)			Avg. (^oC)
	V	A	Q	T1	T2	T3	T_A	T4	T5	T6	T_B	T7	T8	T9	T_C

CALCULATION:

1. Plot the temperature vs. radius to get radial temperature distribution.

2. Find the conductivity of the insulation.

Exp. No. 6	**Title:** Heat Transfer through Lagged Pipe Apparatus.
Name of Student:	
Roll No.:	
Date of Experiment:	
Date of Submission:	

Signature of Teacher with Date of Check **SEAL**