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File No:

SRI KRISHNA INSTITUTE OF TECHNOLOGY, BENGALURU



COURSE PLAN

Academic Year 2019 - 20

Program:	BE
Semester :	6/A
Course Code:	17MEL67
Course Title:	Heat Transfer Lab
Credit / L-T-P:	2/ 1-0-2
Total Contact Hours:	30
Course Plan Author:	APPESE S D

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Buildings Mechanical systems Refrigeration Spacecraft Automotive	0 ب . ۵۸
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17MEL67: Heat Transfer Lab

A. LABORATORY INFORMATION

1. Lab Overview

Degree:	BE	Program:	ME
Year / Semester :	3 / 6	Academic Year:	2019-20
Course Title:	Heat Transfer Lab	Course Code:	17MEL67
Credit / L-T-P:	2 / 1-0-2	SEE Duration:	180 Minutes
Total Contact Hours:	30 Hrs	SEE Marks:	60
CIA Marks:	40	Assignment	1
Course Plan Author:	Mr. Appese S D	Sign	Dt:
Checked By:	Mr. Naveen Kumar P	Sign	Dt :

2. Lab Content

Unit	Title of the Experiments	Blooms Level
	Part-A	
1	Determination of Thermal Conductivity of a Metal Rod.	L3
2	Determination of Overall Heat Transfer Coefficient of a Composite wall	L3
3	Determination of Effectiveness on a Metallic fin.	L3
4	Determination of Heat Transfer Coefficient in a free Convection	L3
5	Determination of Heat Transfer Coefficient in a Forced Convention Flow through a Pipe.	L3
6	Determination of Emissivity of a Surface.	L3
7	Analysis of steady and transient heat conduction, temperature distribution of plane wall and cylinder using Numerical approach (ANSYS/CFD package).	L3
	Part-B	
1	Determination of Steffan Boltzmann Constant.	L3
2	Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Ex-changers.	L3
3	Experiments on Boiling of Liquid and Condensation of Vapour.	L3
4	Performance Test on a Vapour Compression Refrigeration	L3
5	Performance Test on a Vapour Compression Air – Conditioner	L3
6	Experiment on Transient Conduction Heat Transfer.	L3
7	Determination of temperature distribution along a rectangular and circular fin subjected to heat loss through convection using Numerical approach (ANSYS/CFD package)	L3

3. Lab Material

Details	Available
Text books	
M. Necati Ozisik, Heat Transfer – A Basic Approach, McGraw Hill, New	In Lib
York,2005.	
Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, 5 th	In Lib
Edition, John Wiley and Sons, New York, 2006.	
Holman, J. P., Heat Transfer, 9th Edition, Tata McGraw Hill, New York, 2008.	In Lib/Dept Lib
	Details Text books M. Necati Ozisik, Heat Transfer – A Basic Approach, McGraw Hill, New York,2005. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, 5 th Edition, John Wiley and Sons, New York, 2006. Holman, J. P., Heat Transfer, 9th Edition, Tata McGraw Hill, New York, 2008.

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4. Lab Prerequisites: Performance Test on a Vapour Compression Refrigeration

SNo	Course	Course Name	Topic / Description	Sem	Remarks
	Code				
1	17ME33	Basic	Fundamentals, Work and Heat Interactions	3	-
		thermodynamics			
2	15MEL57	Fluid mechanics	Fluid properties, Fluid flows, variation in	4	-
			fluid flows, turbulent and laminar flow.		

5. General Instructions

S No	Forced convection systems applicable for extremely high temperatures for functions Instructions	Remarks
1	Observation book and Lab record are compulsory.	
2	Students should report to the concerned lab as per the time table.	
3	After completion of the program, certification of the concerned staff in-charge in the observation book is necessary.	
4	Student should bring a notebook of 100 pages and should enter the readings /observations into the notebook while performing the experiment.	
5	The record of observations along with the detailed experimental procedure of the experiment in the Immediate last session should be submitted and certified staff member in-charge.	
6	Should attempt all problems / assignments given in the list session wise.	
7	It is responsibility to create a separate directory to store all the programs, so that nobody else can read or copy.	
8	When the experiment is completed, should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.	
9	Any damage of the equipment or burn-out components will be viewed seriously either by putting penalty or by dismissing the total group of students from the lab for the semester/year	
10	Completed lab assignments should be submitted in the form of a Lab Record in which you have to write the algorithm, program code along with comments and output for various inputs given	

6. Lab Specific Instructions

S No	Specific Instructions	Remarks
1	Students must attend the lab classes with ID cards and in the prescribed uniform.	
2	Students must check if the components, instruments and machinery are in working condition before setting up the experiment.	
3	Power supply to the experimental set up/ equipment/ machine must be switched on only after the faculty checks and gives approval fording the experiment. Students must start to the experiment. Students must start doing the experiments only after getting permissions from the faculty.	
4	Students may contact the lab in charge immediately for any unexpected incident sand emergency	
5	The apparatus used for the experiments must be cleaned and returned to the technicians, safely without any damage	
6	Make sure, while leaving the lab after the stipulated time, that all the power connections are switched off	

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B. OBE PARAMETERS

1. Lab / Course Outcomes

S no	CO s	Teach.	Instr Method	Assessment	Blooms'
		Hours		Method	Level
CO1	Perform experiments to determine the thermal	6	Demonstration,	Practical	L3
	conductivity of a metal rod		Video, chalk and	record and IA	
			Board	test	
CO2	Conduct experiments to determine convective	6	Demonstration,	Practical	L3
	heat transfer coefficient for free and forced		Video, chalk and	record and IA	
	convection and correlate with theoretical		Board	test	
	values.				
CO3	Estimate the effective thermal resistance in	6	Demonstration,	Practical	L3
	composite slabs and efficiency in pin-fin		Video, chalk and	record and IA	
			Board	test	
CO4	Determine surface Emissivity of a test plate	6	Demonstration,	Practical	L3
			Video, chalk and	record and IA	
			Board	test	
CO5	Estimate performance of a refrigerator and	6	Demonstration,	Practical	L3
	effectiveness of fin		Video, chalk and	record and IA	
			Board	test	
-	Total	30	-	-	-

2. Lab Applications

S No	Application Area	Level
1	Air conditioning, Fins in all system, Fans, refrigerator, Engine Radiators, cooling heat pipes	L3
	in electronic Appliances,	
2	To compute the heat flux at any location, compute the thermal stress, design of insulation	L3
	thickness, chip temperature calculation, heat treatment of metals.	
3	Buildings, Mechanical systems, Refrigeration, Spacecraft, Automotive	L3
4	Metallurgy, heat treating process applications.	L3
5	2-D study state heat conduction equation is applied in CFD analysis(Finite difference and	L3
	finite element method)	
6	Solar flat plate collector, water heating process (solar pond), photo voltaic cell.	L3
7	To compute the heat flux at any location, compute the thermal stress, design of insulation	L3
	thickness, chip temperature calculation, heat treatment of metals.	
8	Forced convection systems applicable for extremely high temperatures for functions	L3
9	Establishing temperature distribution within building, determining heat loss calculations,	L3
	ventilating and air-conditioning system.	
10	Boiling and condensation knowledge is applicable to calculate critical heat flux, and	L3
	condensation rate in heat transfer problems.	
11	LMTD and NTU methods for analysis of heat ex-changers.	L3
12	Buildings, Mechanical systems, Refrigeration, Spacecraft, Automotive	L3



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3. Articulation Matrix

(CO – PO MAPPING)

-	Course Outcomes	Program Outcomes												
#	COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	Level
		1	2	3	4	5	6	7	8	9	10	11	12	
CO1	Perform experiments to	\checkmark	\checkmark	-	-	-	-	-	-	\checkmark	-	-	-	L3
	determine the thermal													
	conductivity of a metal rod													
CO2	Conduct experiments to	\checkmark	\checkmark	-	-	-	-	-	-	√	-	-	-	L3
	determine convective heat													
	transfer coefficient for free and													
	forced convection and correlate													
	with theoretical values.													
CO3	Estimate the effective thermal	\checkmark	\checkmark	-	-	-	-	-	-	\checkmark	-	-	-	L3
	resistance in composite slabs													
CO4	D4 Determine surface Emissivity of a test plate			-	-	-	-	-	-	\checkmark	-	-	-	L3
CO5	Estimate performance of a			-	-	-	-	-	-		-	-	-	L3
	refrigerator and effectiveness of													
	fin													

4. Mapping Justification

Mappir	ng	Mapping	Justification							
		Level								
СО	PO	-	-							
CO1	PO1	L2	Knowledge of engineering fundamentals is required to understand the thermal conductivity .							
CO1	PO2	L3,L4	Analyzing problem in thermal conductivity of a given metal rods.							
CO1	PO9	L3	Individual work, mapping							
CO2	PO1	L2	Knowledge of engineering fundamentals is required to understand the temperature difference between different layers of composite walls.							
CO2	PO2	L3.L4	Analyzing overall heat transfer coefficient in a different composite walls.							
CO2	PO9	- ,	ndividual work mapping							
CO3	PO1	L2	Knowledge of temperature difference is required to understand thermal resistance.							
CO3	PO2	L3,L4	Analyzing surface heat transfer coefficient for a fin loosing heat by forced convection.							
CO3	PO9	-	Individual work, mapping							
CO4	PO1	L2	Knowledge of modes of heat transfer is required to understand convective heat transfer coefficient							
CO4	PO2	L3,L4	Analyzing heat transfer inn liquids and gasses.							
CO4	PO9	-	Individual work, mapping							
CO5	PO1	L2	Knowledge of Newtons law of cooling is required to understand rate of convective heat transfer.							
CO5	PO2	L3,L4	Analyzing solid surface to fluid layer by conduction.							
CO5	PO9	-	Individual work, mapping							



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C. COURSE ASSESSMENT

1. Course Coverage

Unit	Title	Teachi	hi No. of question in Exam							Levels
		ng	CIA-1	CIA-2	CIA-3	Asg-1	Asg-2	Asg-3	SEE	
		Hours								
	PART-A									
1	Determination of Thermal Conductivity of a Metal Rod.	03	1	-	-	-	-	-	1	L3
2	Determination of Overall Heat Transfer Coefficient of a Composite wall	03	1	-	-	-	-	-	1	L3
3	Determination of Effectiveness on a Metallic fin.	03	1	-	-	-	-	-	1	L3
4	Determination of Heat Transfer Coefficient in a free Convection	03	1	-	-	-	-	-	1	L3
5	Determination of Heat Transfer Coefficient in a Forced Convention Flow through a Pipe.	03	1	-	-	-	-	-	1	L3
6	Determination of Emissivity of a Surface.	03	1	-	-	-	-	-	1	L3
7	Analysis of steady and transient heat conduction, temperature distribution of plane wall and cylinder using Numerical approach (ANSYS/CFD package).	03	-	-	-	-	-	-	1	L3
	PART-B									
1	Determination of Steffan Boltzmann Constant.	03	1	-	-	-	-	-	1	L3
2	Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Ex-changers.	03	1	-	-	-	-	-	1	L3
3	Experiments on Boiling of Liquid and Condensation of Vapour.	03	1	-	-	-	-	-	1	L3
4	Performance Test on a Vapour Compression Refrigeration	03	1	-	-	-	-	-	1	L3
5	Performance Test on a Vapour Compression Air – Conditioner	03	1	-	-	-	-	-	1	L3
6	Experiment on Transient Conduction Heat Transfer.	03	1	-	-	-	-	-	1	L3
7	Determination of temperature distribution along a rectangular and circular fin subjected to heat loss through convection using Numerical approach (ANSYS/CFD package)	03	1	-	-	-	-	-	1	L3 _
	ivlai			1	1	1				

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Evaluation	Weight age in Marks	CO	Levels		
CIA Exam – 1	30	30 CO1, CO2, CO3, CO4,CO5			
Assignment – 1	5	CO1, CO2, CO3, CO4,CO5	L3		
Other Activities – define – Slip test	5	CO1 to CO5	L3		
Final CIA Marks	40	-	-		

D. EXPERIMENTS

Experiment 01: Determination of Thermal Conductivity of a Metal Rod.

-	Experiment No.:	1	Marks		Date Planned		Date Conducted		
1	Title	Detei	Determination of Thermal Conductivity of a Metal Rod						
2	Course Outcomes	Perfo	rm experim	ents to o	determine the	thermal con	ductivity of a m	etal rod	
3	Aim	To de	etermine the	e therma	l conductivity	of the given	metal rod		
4	Material / Equipment Required	Meta	l rod, Heate	er, Rota-i	meter, Therm	ocouples, Po	wer supply par	nel, etc.	
5	Theory, Formula, Principle, Concept	Therr chem it exi which	Thermal conductivity is a physical property of a material and depends on the chemical composition of the substance, the phase (solid, liquid or gas) in which texists, its crystalline structure if a solid, the temperature and pressure to which it is subjected, and whether or not it is homo-genetic material.						
6	Procedure, Program, Activity, Algorithm, Pseudo Code	1. No 2. Sw to 1L 3. Se 4. Aft temp T_9 (w 5. Re therm each	1. Note down the specifications of the equipment. 2. Switch on the mains, Heater and maintain a steady water flow, say 0.5 LPM to 1LPM through the rota-meter. 3. Set the temperature to a particular safe value through Dimmer stat. 4. After steady state conditions are established (around 20 minutes), record the temperatures of Thermocouples along the rod $T_2 - T_7$ and T_8 (water inlet) and T_9 (water outlet) temperatures. 5. Repeat the experiment for various input conditions (V and I) to obtain the thermal conductivity of the rod at the corresponding average temperatures in						
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph		Circulatin Water Inlet Water ← Outiet			itation Chaik howe	Metal Rod Hear Hear Hear Hear Hear Hear Hear Hear	IBT +	

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			I = Current (amps)																	
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10	Graphs	, Outputs		T'C dT T^2 T^3 T^3 T^7 dX $T7$		
11	Results	& Analysis		 The thermal conductivity of given material was found to k =W/ m-K. Point for Discussion Compare the experimental value of k with the standard temperature of the set of observations. Is there any specific reason why the water jacket is citizen the rod. Comment on it. 	be rd value at the average irculated on one end of	
12	12 Application Areas Air conditioning, Fins in all system, Fans, refrigerator, Engine Radiators cooling heat pipes in electronic Appliances,					
13	Remarl	s				
14	Faculty Date	Signature	with			

Experiment 02 : Determination of Overall Heat Transfer Coefficient of a Composite wall

-	Experiment No.:	2	Marks		Date Planned		Date Conducted				
1	Title	Dete	ermination of	Overall Heat	all Heat Transfer Coefficient of a Composite wall						
2	Course Outcomes										
3	Aim	To [To Determine the overall heat Transfer coefficient of a composite wall								
4	Material / Equipment Required	Give Terr	Siven Composite wall, Heater, Set of Thermocouples, Power Supply panel, Channel emperature Indicator and necessary connections.								
5	Theory, Formula, Principle, Concept	The in se of p exai etc., wall prot cone syst neg	composition eries or parall practical utility mple, the wa which alway s. The proce olems for co centric spher em are in pe ligible, i.e, the	of two or mo lel is called co / involve hea Il of a refrige s have some edure for sol mposite syste es. It will be erfect thermal e temperature	re materials omposite mat at transfer the rator, hot can kind of insula ving one-din ems comprise assumed the contact or t continuous a	of different therial (wall).M rough composes; cold stor ating material nensional, stor sing parallel nat the paral he resistance at the interfact	nermal conduction any engineering site materials. rage plants hot between the in eady state hea plates, coaxial lel layers in the due to interfa-	vity arranged g applications Consider for water tanks, ner and outer at conduction cylinders or ne composite ace contact is in contact.			

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6	Proced	ure,	• 5	Switch on th	e mains	and	con	sole	/—·												
	Progra	m, Activity,	• 5	bet the wate	er flow ra	te to	1-2	Ipm	(⊢D) • • • •	xed).											
	Algoritr	im, Pseudo	• 1	ne neat inp	out to the	nea roac	ter is	S TIX	ea t	or ar	ny desired val	Je. the clobe at the i	ntor								
	Code		f:	aces are no	sidle is	Teac	neu	, av	eraç	je ie			niei								
			• E	Bv varving	the hea	t inpi	ut to	o the	e sv	/ster	n through va	riac. different set	s of								
			r	eadings car	n be obta	, ained					Ū	,									
			F	Repeat the a	above op	perati	ions	for	give	n He	eat inputs.										
7	Block,	Circuit,									Water										
	Model	Diagram,			Steel pla	ite					circulation										
	Reactio	on Equation,		water out																	
	Expect	ed Graph			T ₉						·: . : : : : : : T _s										
					stainless_ steel																
					Copper																
					siab		/////// YYY		//////////////////////////////////////	//////////////////////////////////////	Hea	er									
							$\Delta \Delta$	\sim		<u> </u>											
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					Concession of the second secon			3													
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						The ground a				•	-										
8	Observ	ation Table,	SI Volta	Current	Terr	pera	ture	s (⁰	C)		Water in	let Water outle	et								
	Look-u	p Table,	No ge	ʻ '	T ₁ T ₂	T _a	Т	T _c	T _a	Т.,	temperature	temperature									
	Output		' V '	Amps		• 3	• 4	• 5	• •	• /	T ₈ (°C)	T ₉ (°C)									
			Volts	;																	
-	O como d					.:		 י _ ר	1.	, ,											
9	Calcula	e Itions	(a) Heat f	ow through	compos	SITE W	all C	י = ג	νх	ı. (vv)										
	Saloule		k. A	$(T_2 - T_1)$) k.	4.(7	· —	T_{-}		<i>k</i> . 4	$f_{a}(T_{c}-T_{c})$										
			$Q = \frac{n_1 n_2}{2}$	L_1	$- = \frac{w_2}{2}$	$\frac{-2}{L}$	4	-5)	- =	<u>w</u> 32	$\frac{I_3(I_6 I_7)}{I_2}$	(1)									
			k₁= Therm	1 nal conducti	ivity of M	ے ایا hlil	∠ teel	I	₁ =	thick	mess of Mild	Steel									
			$k_2 = Therr$	nal conduct	tivity of \	Vood	 I.	L	-ı =	thick	ness of wood										
			k₃ = Therr	nal conduc	tivity of c	oppe	er.	-	_ L ₃ =	thic	kness of cop	ber.									
			From equ	ation(1)	-							k_3 = Thermal conductivity of copper. L_3 = thickness of copper. From equation(1)									

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			$k_{1} = \frac{QL_{1}}{A_{1}(T_{2} - T_{3})}, \text{Where } A = \frac{\pi d^{2}}{4} \implies d = \text{Diamet}$ $k_{2} = \frac{QL_{2}}{A_{2}(T_{4} - T_{5})}, A_{1} = A_{2} = A_{3} = A.$ $k_{3} = \frac{QL_{3}}{A_{2}(T_{4} - T_{5})},$	er of the slab	
			$A_3(I_6 - I_7)$		
			(b) Overall heat transfer coefficient (U _o)		
			1/U _o = $\frac{L_1}{k_1} + \frac{L_2}{k_2} + \frac{L_3}{k_3}$, $(\frac{W}{m^2 - K})$		
10	Graphs	, Outputs	Result: The Overall heat transfer co-efficient of given compose $U_0 = \underline{W}/m-K.$	site slab was found	to
			Points for discussion:-		
			 Comment on the experimental set up,its validity and ac Overall heat transfer co-efficient can also be ca requirement of intermediate temperatures. comment or 	ccuracy. alculated without th n it.	he
11	Results	& Analysis			
12	Applica	tion Areas	To compute the heat flux at any location, compute the ther insulation thickness, chip temperature calculation, heat treatme	mal stress, design ent of metals.	of
13	Remark	s			
14	Faculty with Da	Signature te			

Experiment 03: Determination of Effectiveness of a Metallic fin.

-	Experiment No.:	3	Marks		Date Planned		Date Conducted				
1	Title	Dete	rmination of E	Effectiveness	on a Metallic	c fin.					
2	Course Outcomes	Esti	Estimate the effective thermal resistance and efficiency in pin-fin								
3	Aim	To d force	determine the efficiency and effectiveness of the fin by natural convection and ced convection using pin fin apparatus.								
4	Material / Equipment Required	The whick Ther used stat a and i	experimental h the pin fin mocouples a to measure and measure s measured	set up consi is fitted. Or re embedded flow of air thro d by voltmeter with the help c	sts of a blow ne end of th l on the fin bugh the duc r and ammet of orifice mete	ver unit havin ne pin fin is surface. Blow t. Input to he er. Air flow is er and the ma	ng a rectangula connected to ver along with ater is given th controlled by t anometer fitted	ar duct inside heater. Five the orifice is rough dimmer the gate valve on the board.			
5	5 Theory, Formula, (i) Fins are extended surfaces which are used to increase the rate of heat transfe										

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	Principl	e, Concept	between a surface and the adjacent fluid. Fins are classified	into three viz. angula						
	•	· ·	fins, straight fins and pin-fins. Angular fins are fixed to cylind	rical surfaces, straigh						
			fins and pin fins are fixed to plane surfaces. Fins are u	sed in I.C. Engines						
			Compresses, Radiation, Heat exchanges etc.	-						
			(ii) Natural convection is the heat transfer between a surface	ce and adjacent flui						
			particles due to the macroscopic motion of fluid particles, set	up by buoyancy effec						
			resulting from the density difference caused by their temperatur	e difference,						
			(iii) Fin effectiveness is the ratio of heat transfer with the fir	n to the heat transfe						
			without							
			$\tanh(ml)$							
			fin, It is denoted by, $\Box = \int h \cdot A$.							
			$\sqrt{\frac{k_{f}}{R}}$							
			(iv) Ein officional is the ratio of heat last from the finite the h	aat that would be les						
			when the entire surface of the fin is under base temperature	eat that would be lose it is given by n						
			tanh ml							
			$\frac{ddmm}{ml}$.							
6	Procedu	ure,	(a) Natural Convection:	and here the set						
Program, Activity, 1. Switch on the supply and adjust the variac to obtain the required he Algorithm Results 2 Note down the following readings after reaching the steady state:										
	Algorith	m, Pseudo	(i) Voltmeter reading 'V' volts	late.						
	Code		(ii) Ammeter reading 'A' amps							
			(iii) Thermocouples readings (T_{\perp} to T_{e}) ⁰ C							
			3. Repeat the procedure for different heat inputs and tabulate th	ie readings.						
				0						
			(b) Forced Convection:							
			1. Switch on the supply and adjust the variac to obtain the requi	red heat input.						
			2. Start the blower, set the manometer head as required.							
			3. Note down the following readings after reaching the steady st	tate:						
			(i) Voltmeter reading 'V' volts							
			(ii) Ammeter reading 'A' amps							
			(iii) Thermocouples readings (T 1 to T 6)°C.							
			(iv) ivianometer reading in cm.	raadinac						
			Repeat the procedure for different neat inputs and tabulate the l	leadings						
7	Block,	Circuit,								
	Model	Diagram,	orifice GI Pipe	De for						
	Reactio	n Equation,	Temperature Indicator							
	Expecte	ed Graph	Voltmeter Voltmeter							
			Dimmerstat Pin fin							
			Fig 3.1(a) Pin fin apparatus							
		Fig 3.2(b) Pin fin enlarged								
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8	Observ Look-uţ Output	ation Table, o Table,	SI. No.	Volta ge (V) Volts	Current amps	Power Q=VI Watts	Temperature at different point in the outer surface of cylinder (°C)					h _{the} W/m²- K	η_{the} (%)	η _{exp} (%)	3	
								Та	Та	т.	Т	Та				
								12	13	• 4	15	16				
9 Sample Calculations (1) Experimental Efficiency The efficiency of the pin fin Where, $Q_{fin} = V \times I$, W $(Q_{fin})_{max} = h_{exp}.A_S.(T_A)$ But, $h_{exp} = Q_{fin} / \{As \ (Ts - Ta) A_S = \pi.d.I. \ (m^2) \}$ (2) Theoretical Efficiency of $\eta_{the} = \frac{\tanh ml}{ml}$ Where, $m = \sqrt{\frac{h.P}{k_f.A}}$ $h = heat transfer coefficientP = Perimeter of fin (\pi D)k_f = thermal conductivity ofA = Area of fin = \frac{\pi.d^2}{4}, (I = Length of pin fin, mTo find heat transfer coefficient$						ncy of pir fin exper ($T_s - T_a$) - Ta) y of pin fin of pin fin , (d = Di efficient o ure, $T_f = -$	$n fin($ $rimer$ η_{ex} $+ \sigma.$ $n(\eta_{th}$ $n = 1^{-1}$ ame $f fin($ $\frac{Ts + 2}{2}$	(η_{exp}) htally $p = ((M_{AS}, (M_{AS})))$ (η_{exp}) $(M_{AS}, (M_{AS}))$ $(M_{AS}, (M_{AS}))$ (M_{AS}) $(M_{AS$	F is given by Q_{fin} , Q_{fin} , Q_{fin} , $T_s^4 - T_s^4 - W_m - f$ the (°C	(ven k $\frac{m}{max}$ T_a^4), $\frac{1}{K}$) pin fi	νy W), m	1 ²			

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			Where, T_s = Surface temperature of the cylinder =	$\frac{T_2 + T_3 + T_4 + T_5 + T_6}{5}$									
				3									
			(К)										
			$T_a = T_{1,a}$ mbient temperature (K)										
			Properties of air at the film temperature (T_{f}) is obtained fi	rom data book, hence									
			determine										
			Kinematic viscosity, v = Thermal conductivity, k =										
			Prandtl number, Pr =										
			(ii) Grassoff number Gr = $\frac{g \cdot \beta \cdot \Delta T \cdot d^3}{v^2}$										
		1	Where,										
			β = Co-efficient of thermal expansion = $\frac{1}{(T_f + 273)}$. (K ⁻¹)									
			$\Delta T = T_f - T_1. (K)$										
			d = Diameter of the pin fin. (m)										
			v = Kinematic viscosity. (m^2/s) ×										
			\therefore Ra. No= Gr x Pr =										
			From heat transfer Data hand book corresponding to this valu Ra, the nusselt number(Nu) is given by Forced convection systems applicable for extremely high tem	e of Rayleigh number									
			$0.67 \times (Gr \times Pr)^{0.25}$										
			For $10^{-1} < \text{Gr} \times \text{Pr} < 10^4$, Nu = 0.68 + $\left\{ 1 + \left[\frac{0.492}{\text{Pr}} \right]^{0.5625} \right\}^{0.44}$	4									
			For $10^4 < \text{Gr} \times \text{Pr} < 10^9$, Nu = 0.59 (Gr $\times x \text{Pr}$) ^{0.25}										
			For $10^9 < \text{Gr} \times \text{Pr} < 10^{12}$, Nu = 0.13 (Gr x Pr) ^{0.33}										
			Hence,										
			$Nu = \frac{h.l}{k}$. Or										
			$h = \frac{Nu.k}{l}.$										
		,	Where, h= h _{the} = natural heat transfer co-efficient, $(\frac{W}{m^2 - K})$										



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		(3) Effectiveness of Fin, $\varepsilon = \frac{\tanh(ml)}{\sqrt{\frac{h.A}{k_f.P}}}$
10	Graphs, Outputs	
11	Results & Analysis	Result:- free convection h _{the} =, η _{exp} =, ε = forced convection h _{the} =, η _{exp} =, ε = Points for discussion:- (1) If the readings are taken when the steady state is yet to be reached, how will the accuracy of the results will be affected. (2) From the observations taken in this experiment, explain how would you determine the thermal conductivity of the material of the fin.
12	Application Areas	Buildings, Mechanical systems, Refrigeration, Spacecraft, Automotive
13	Remarks	
14	Faculty Signature with Date	

Experiment 04 :Determination of Heat Transfer Coefficient in a free Convection

-	Experiment No.:	4	Marks		Date Planned		Date Conducte d			
1	Title	Dete	rmination of I	leat Transfer	Coefficient ir	n a free Conv	ection			
2	Course Outcomes	Con	Conduct experiments to determine convective heat transfer coefficient							
3	Aim	To d	To determine Heat Transfer Coefficient in a free Convection							
4	Material / Equipment Required	The posit serve in the tube tube by a is po	The apparatus consists of a brass tube fitted in a rectangular duct in a vertical position. The duct is open at the top and bottom and forms an enclosure and serves the purpose of undisturbed surrounding. An electric heating element is kept in the vertical tube which in turn heats the tube surface. The heat is lost from the tube to the surrounding air by natural convection. The temperature of the vertical tube is measured by six Thermocouples. The heat input to the heater is measured by an Ammeter and a Voltmeter and is varied by a dimmer stat. The tube surface is polished to minimize the radiation losses.							
5	Theory, Formula, Principle, Concept	natur coils the r the c rate	ral convection etc. It is heat nacroscopic r density differe (Q) in free co $Q = hA_s(T_s - T_s)$ Where, A_s	n is the mod at transfer be motion of fluid ence caused nvection is gi 「∞) - Surface are	e of heat tra tween a surfa d particles, se by their tem ven by Newto ea. (m ²)	insfer from h ace and adja et up by buoy perature diffe on's law of co	ot radiators, re cent fluid partio ancy effect res erence. The he oling given by	efrigerating cles due to ulting from eat transfer		

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			(Ts⊸ h - I air)	- T∞) - ⁻ Heat tr	Temp ansfe	eratur er co-e	e dif fficie	fere ent (nce usu:	betv ally {	wee 5 to	n th 25 (e su (W^2	ce and fluid $\frac{1}{K}$) for nation	d. (K tural) convecti	on for
6	6 Procedure, Program, Activity Algorithm, Pseudo Code			 Switch on the electric heater and adjust the auto transformer. Wait for steady state to be reached. Note down the required readings like Voltage, Current and Thermocouples eadings T₂ – T₇ along the rod Calculate heat transfer co-efficient for natural convection. Also determine the heat transfer co-efficient using the empirical relation compare 														
7	Block, Model Reactic Expecte	Circuit, Diagram, on Equation, ed Graph							E T UWatt	rass ube < meter nersta	ECTION			Heat Eler	ting ment (T2- T7) nelosure	5		
8	8 Observation Table, Look-up Table, Output 9 (` Vo			Volta ge (V) Volts	Cur rent am ps	Pow er Q=V I Watt s	pc T1	Γem bint i T ₂	pera n th cy T ₃	ature e ou linde T ₄	e at iter s er (⁰ T₅	diffe surfa C) T ₆	ereni ace T ₇	t of T ₈	Manome Reading H _w = (h ₁ + h ₂) x ³ , m	eter gs 10 ⁻	Heat tra co-effic W/m ² h _{exp}	nsfer :ient -K h _{the}

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															-			-	
9	Sample	•	I. Exp	perime	ntal N	/lethoc	1												
	Calcula	tions	Experimental heat transfer co-efficient, $h_{exp} = \frac{Q}{A_{c}(T_{c} - T_{c})}$.																
			$A_{S}(I_{S} - I_{a})$ Where																
			vvnere Q = Rate of heating, = V x I. watts.																
			$A = \pi dl$,																
			Where,																
			d = Diameter of cylinder rod. (m)																
			II. An	alytica	י l (The	eoretic	al) N	/eth	nod	<i>.</i> (1	,								
			(i	(i) Film temperature, $T_f = \frac{T_s + Ta}{2}$. (°C)															
								- 				1							
	T_s - Surface temperature of the cylinder - $T_{+}T_{+}T_{+}T_{+}T_{+}T_{+}T_{+}T_{+}$																		
			121	13 11	4 ' <u>'</u> : 7	5 1 1 6	117	11	° ('	°C)									
					, Ta	= amł	pient	ten	nper	atur	e.	(°C))						
			Prope	erties	of air	at the	e filr	n te	emp	eratı	ure	(T _f)	is c	obta	ined fro	om dat	a book,	, hence	
			determine																
			Kinematic viscosity, v = Thermal conductivity, k =																
			Prandtl number, Pr =																
			(ii) Grassoff number Gr = $\frac{g \cdot \beta \cdot \Delta T \cdot l_c^3}{V^2}$																
			Wher	e,															
				β = Co	-effic	ient of	ther	ma	l exp	bans	ion	= _(T_f -	1 + 27	73). (1	≺⁻')			
			Δ	Γ = Τ _f -	T₁. (K)													
				$I_c = cha$	aracte	eristic	leng	th =	len	gth o	of th	ne ve	ertica	al cy	linder .	(m)			
				v = Kir	nemat	tic viso	cosit	y. (m²/s	5)									
			Ra.No = Gr x Pr =																
			From numb For 1	The mean mean set of the set of							Rayleigh								
			For 1	0 ⁴ < G	r x Pı	r < 10 ⁹	, N	lu =	0.5	9 (G	ir ×	< P	r) ^{0.25}						
			F	or 10 ⁹	< Gr	<i>x</i> Pr <	10 ¹²	² , N	√u =	0.1	3 (G	Gr ×	< Pi	r) ^{0.33}	3				
			Hen	ce,															

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			$Nu = \frac{h_{theo}.d}{k} . \text{ or}$ $h_{the} = \frac{Nu.k}{l} .$ Where, h_{the} = Theoretical heat transfer co-efficient, $(\frac{W}{m^2 - K})$ The heat transfer co-efficient for the vertical tube was four	nd to be
			$\frac{W}{m^2 - K}$	
10	Graphs	, Outputs		
11	Results	& Analysis	 Result : The co-efficient of heat transfer by experiment is h_{exp} = The co-efficient of heat transfer by theoretical is 	ation. pefficient obtained
12	Applica	tion Areas	Metallurgy, heat treating process applications.	
13	Remar	٢S		
14	Faculty with Da	Signature ite		

Experiment 05 :Determination of Heat Transfer Coefficient in a Forced Convention Flow through a Pipe

-	Experiment No.:	5	Marks	D Pla	ate Inned	Date Conducted				
1	Title	Dete Pipe	Determination of Heat Transfer Coefficient in a Forced Convention Flow through a Pipe							
2	Course Outcomes	Cono conv	Conduct experiments to determine convective heat transfer coefficient for forced convection.							
3	Aim	To d giver	To determine the Forced Convection heat transfer coefficient for flow through the given Horizontal tube cylinder							
4	Material / Equipment Required	The section test section and pipe	experimental on is surroun section and t exit of the ter is connecter	set up consists of ded by band heate wo thermo couple at section to meas d to the delivery	a blower unit fit r. Seven thermo s are placed in ure the air inlet side of the blo	ted with the test pipe occouples are embed the air stream at the and outlet temperat ower along with the	e. The test ded on the e entrance ures. Test orifice to			

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			measure flow of air through the pipe. Input to heater is given and measured by voltmeter and ammeter. Air flow is controlled and is measured with the help of orifice meter and the mano board.	through dimmerstat d by the gate valve meter fitted on the
5	Theory, Principl	Formula, e, Concept		
	Procedu Progran Algorith Code	ure, n, Activity, m, Pseudo		
7	Block, Model Reactio Expecte	Circuit, Diagram, n Equation, ed Graph	Temperature Indicator Anmeter Voltmeter Dimmerstat Dimmerstat Test Section To U-Tube Manometer Blower	
8	Observa Look-up Output	ation Table, D Table,		
9	Sample Calcula	tions	I. Experimental Method Experimental heat transfer co-efficient, h _{exp} = Q /A _s (Ts - Ta) Where Q = Rate of heating, = V x I, watts. A _s = πdl, Where, d = Diameter of cylinder rod I = length of cylinder II. Analytical (Theoretical) Method	
		7	Dana # 20 / 40	

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			(1) Bulk mean temperature $T_{r} = T_{r} + T_{r} / 2$ (°C)									
			(1) Duk mean temperature, $1f = 1_1 + 1_7 + 2$. (C)									
			T = Air outlet temperature (°C)									
			$\Gamma_7 = A \Pi$ outliet temperature. (C)	, data baak, banaa								
			determine	i data book, nence								
			Density, $\rho = $ Specific heat, $C_{\rho} =$									
			Kinematic viscosity, v = Thermal conductivity, k =									
			Prandtl number Pr									
			(2) Discharge q = $C_d A_0 \sqrt{2.G.H_a}$									
			Where.									
			C_d = Co-efficient of discharge = 0.65									
			πd^2									
			$A_0 = \frac{d_0}{4} d_0 = Diameter of orifice$									
			H_a = Head of air = $\rho_w H_w / \rho_a$									
			$\rho_w = 1000 \text{ kg/m}^3$									
			$\rho_a = 1.2 \text{ kg/m}^3$									
			(3) Velocity v = $\frac{q}{A}$. (m/s)									
			(4) Reynold's No. Re = vd / v									
			d = Diameter of the cylinder. (m)									
			v = Velocity of the air. (m/s)									
			From heat transfer Data hand book corresponding to this v	alue of Reynolds								
			number, the nusselt number(Nu) is given by									
			Nu = 0.618 (Re) ^{0.466} , if 40 < Re < 4000									
			Nu = 0.174 (Re) ^{0.618} , if 4000 < Re < 40,000.									
			Hence,									
			$Nu = \frac{h_{theo}.d}{k} . Or$									
			N. L									
			$h_{\text{theo}} = \frac{I V \mathcal{U} \cdot \mathcal{K}}{I}$.									
			a									
			Where, h_{theo} = Theoretical heat transfer co-efficient, $(\frac{W}{m^2 - K})$	-)								
10	Graphs	, Outputs										
11	Results	& Analysis	s Result : The co-efficient of heat transfer by experiment is									
			h _{exp} =									
			The co-efficient of heat transfer by theoretical is									
			h _{theo} =									
			Points for Discussion :									
			(1) List of various precautions observed during experimentation									
			(2)Comment upon the values of heat transfer coefficient obta	ined experimentally								
			and the one by using correlations.	, · J								

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12	12 Application Areas		2-D study state heat conduction equation is applied in CF difference and finite element method)	D analysis(Finite
13	Remark	(S		
14 s	Faculty with Da	Signature te		

Experiment 06 : Determination of Emissivity of a Surface.

-	Experiment No.:	6	Marks		Date Planned		Date Conducte d			
1	Title	Dete	rmination of E	Emissivity of a	a Surface.					
2	Course Outcomes	Dete	rmine surface	emissivity o	f a test plate					
3	Aim	To de	etermine the	emissivity of	grey body at t	emperature.				
4	Material / Equipment Required	black	olack body, test body, heater, digital voltmeter Ammeter, control body.							
5	Theory, Formula, Principle, Concept	Thern temp radia The s by " s powe powe Emis 1.A bod as	mal Radiatio erature. In α tion heat tran amount of en Stefan Boltzm Wl er)) esivity(ε) of a surface with y ".For real su	n is the end contrast to h isfer does not ergy (E) emit hann law" as $E = \varepsilon \sigma$ here, E = En σ = Ste T = Ab $\varepsilon = Em$ body is a dir $\varepsilon = 1$ is call urfaces $\varepsilon < 1$. H $E_b = \sigma^2$ 1) and (2), it f $\varepsilon = \frac{E}{E_b}$	ergy emitted eat transfer require a me ted by the su T^4 hergy emitted fan boltzsman solute tempe issivity of a b mensionless ed a perfect lence Equati T^4 follows that	by a body through con edium and ca inface of a bo per unit surfa n constant = f rature of the ody. number and radiator an on (1) for a b	as a result of vection and of n occur in vacu dy via radiation . (1) ace of the bod 5.669×10 ⁻⁸ . (surface. (K). can vary betw d is called a black body car (2) (3)	of its finite conduction, uum. ins is given y(Emissive $\left(\frac{W}{m^2 - K^4}\right)$ ween 0 and is a" black in be written		
6	Procedure, Program, Activity, Algorithm, Pseudo Code	(1) (2) (3) (Switch on th to suitable Switch on the than that of Observe the t	e heater to th value using r e heater to th input to the b emperature c	e black-body egulator. e test body & lack body. f black body	& adjust the & keep the po & test surface	power input to ower input to a e in closed tim	o the heater a value less e interval &		

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				adiı	ust po	wer	inpi	ut to	the t	est bo	odv	heat	ter suc	ch that be	oth black bo	dy & test
				surf	ace te	emp	erati	ures	are a	almost	sai	me.				
			(4)	Wait	till th	e si	tead	lv sta	ate is	s read	chec	d. re	cord t	he input	power to h	eaters &
			()	tem	perati	ure	of	arev	bod	v. bla	ack	bod	v & e	enclosure	e now calc	ulate the
				Emi	ssivity	/.		0,					5			
7	Ohaan	otion Toble		Crow body roadings - Black body readings - Dear												
1			Grey body			readings			Bla	ck boo	ly re	eadir	ngs	Room	Enclosure	
						S	Surfa	ice				Surfa	ace	Temp	Temp.	Emissi-
	Output			Volt	Curr	te	mp.((°C)	Vol	Curr	te	emp.	(°C)	I₁(°C)	I ₈ (°C)	vitv
			SI.	age	ent	Т	Т	Т.	tag	ent	Τc	Т	T-	-		ε
			No	V2	I ₂	12	13	• 4	е	I ₁	•5	• 6	' /			
									V ₁							
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								<u> </u>								
												<u> </u>				
8	Block.	Circuit.						Temper	ature Indi	cator	Amn	neter	Voltmeter			
	Model	Diagram,							1				/			
	Reactio	n Equation,														
	Expecte	ed Graph		Dimmerstat Black Body												
	-															
						G	rey Body	y I								
									Bl	ack Body		Grey I	Body			
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9	Calcula	tions	Heat supplied to grey body - $Q_g = V_g \times I_g$													
	Calcula	10115	Also, $Q_g = \varepsilon_g \times \sigma \times A \times (I_g - I_8)$ (4)													
			Where, A_g = area of the grey body													
			$\varepsilon_{\rm b}$ = Emissivity of Grey body													
			σ = Stefan boltzsman constant = 5.669×10 ⁻⁸ .													
					T_ = /	Ava.	. gre	y bor	dy te	mpera	atur	e = -	$T_{2} + T_{1}$	$_{3} + T_{4}$		
	$T_g = Avg. grey body temperature = \frac{3}{3}$															

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			T ₈ = Enclosure Temperature.	
			Heat supplied to black body- $Q_b = V_b \times I_b$	
			Also, $Q_g = \varepsilon_b \times \sigma \times A \times (T_b^4 - T_8^4)$ (5)	
			Where, A_{b} = area of the black body	
			ε_{b} = Emissivity of black body	
			σ = Stefan boltzsman constant = 5.669×10 ⁻⁸	
			T_{b} = Avg. black body temperature = $\frac{T_{5} + T_{6}}{3}$	$+T_{7}$
			T ₈ = Enclosure Temperature.	
10	Graphs	, Outputs		
11	Results	& Analysis	Result: - The experiment is successfully completed the res	ults tabulated in
			tabular column. The Emissivity of given apparatus is \mathcal{E}_{g} =	
			Points for Discussion :	
			1 The value of Emissivity obtained is total is to	otal Emissivity or
			monochromatic Emissivity. What is the difference betwee	en the two.
			2 How and under what conditions Emissivity of a	surface equals its
			absorptivity.	
12	Applica	tion Areas	Solar flat plate collector, water heating process (solar pond), ph	oto voltaic cell.
13	Remarl	<s< td=""><td></td><td></td></s<>		
14	Faculty	Signature		
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Copyright ©2017. cAAS. All rights reserved. COURSE PLAN – CAY 2019-20 BE-5-ME-SKIT-Ph5b1-F02-V2.2 Experiment 07 : Analysis of steady and transient heat conduction, temperature distribution of plane wall and cylinder using Numerical approach (ANSYS/CFD package).

-	Experiment No.:	7	Marks		Date Planned		Date Conducted	
1	Title	Dete	ermination of	Overall Heat	Transfer Coe	fficient of a C	composite wall	
2	Course Outcomes	Und	erstand Over	all Heat Tran	sfer Coefficie	nt of a Comp	osite wall	
3	Aim	Ana wall	lysis of stead and cylinder	y and transie using Numer	nt heat condu ical approach	iction, tempei (ANSYS/CF	rature distributic D package).	on of plane
4	Material / Equipment Required	Give Cha	en Composite nnel Tempera	e wall, Heat ature Indicato	er, Set of T r and necess	hermocouple ary connectio	es, Power Sup ons.	ply panel,
5	Theory, Formula, Principle, Concept	The arra appl Con wate inne heat coax in th inter two	composition nged in serie ications of pl sider for exal er tanks, etc., r and outer conduction kial cylinders he composite face contact layers in contact	n of two or s or parallel is ractical utility mple, the wal which always walls. The pr problems for or concentric system are is negligible, tact.	more mater s called comp involve heat l of a refrigera s have some rocedure for or composite s spheres. It v in perfect the i.e, the temp	ials of differ posite materia transfer thro ator, hot case kind of insula solving one-o systems co vill be assum ermal contact perature cont	rent thermal ca al (wall). Many e ugh composite es; cold storage ating material be dimensional, ste omprising paral ed that the para or the resistar inuous at the in	onductivity ngineering materials. plants hot etween the eady state llel plates, allel layers nce due to nterface of
6	Procedure, Program, Activity, Algorithm, Pseudo Code		 Switch o Set the v The hea After sterning By varyire adings Repeat t 	in the mains a water flow rate t input to the eady state is es are noted. ing the heat is can be obtai the above ope	and console. e to 1-2 lpm (heater is fixed reached, ave nput to the s ned. erations for gi	Fixed). d for any desi erage temper ystem throug ven Heat inpu	red value. ature of the sla h variac, differe uts.	abs at the ent sets of
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph			Steel plate water out T ₅ stainless steel wooden slab Copper slab		Water circulation	Heater	

15	STITUTE OF A	SKIT	Teaching Process Rev No.: 1.0													
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15 * 0	ANGALORE*	Title:	Cou	rse Pla	in									Pag	ge: 26 / 49	9
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8 Observation Table.			SI									outlet				
	Look-uj Output	o Table,	No	ge ' V ' Volts	ʻI' Amps	T ₁	T ₂	T ₃	T ₄	T₅	Τ ₆	T ₇	temperatur T ₈ (°C)	re	tempera T ₉ (°	ture C)
				VOILS												
9	Sample	tions	(a) Heat flow through composite wall Q = V x I. (W) $Q = \frac{k_1 A_1 (T_2 - T_3)}{L_1} = \frac{k_2 A_2 (T_4 - T_5)}{L_2} = \frac{k_3 A_3 (T_6 - T_7)}{L_3} \qquad \dots $							1)						
10	Graphs	, Outputs	Resi to be Poin 3	ult: Tr U₀ hts for 3) Cor	ne Overall =W r discus mment on	hea // m sio i the	at tra -K. n:- expe	insfe	r co	-effi I set	cien	t of	given comp validity and	oosite accur	slab was acy.	found

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			 Overall heat transfer co-efficient can also be cal requirement of intermediate temperatures. comment of 	culated without the on it.			
11	Results	& Analysis					
12	12 Application Areas		To compute the heat flux at any location, compute the thermal stress, design of insulation thickness, chip temperature calculation, heat treatment of metals.				
13	Remark	s					
14	Faculty	Signature					

Experiment 08 : Determination of Steffan Boltzmann Constant.

with Date

-	Experiment No.:	8	Marks		Date Planned		Date Conducte d		
1	Title	Dete	rmination of S	Steffan Boltzr	nann Constar	nt.			
2	Course Outcomes	Able	to determine	the Stefan E	Boltzmann Co	nstant.			
3	Aim	To de	etermine the	value of Stefa	an Boltzmann	constant.			
4	Material / Equipment Require	Copp	ber hemisphe	rical enclosu	re, Thermoco	uples jacket t	o hold hot wat	er.	
5	Theory, Formula, Principle, Concept Power	The B is S The a type of much	The most commonly used law in radiation heat transfer between two bodies A and 3 is Stefan boltzman law which is given as $Q = \sigma \times A \times (T_A^4 - T_B^4)$ Where, Q = Heat transfer rate, W σ = Stefan boltzsman constant = 5.669×10 ⁻⁸ . T_A and T_B = Temperatures of bodies A and B respectively. The above equation is applicable to black bodies & valid only for thermal radiation. Other ype of bodies (like a glossy painted surface or a polished metal plate) do not radiate as nuch energy as the black body but still the total radiation emitted flow this law.						
6	Procedure, Program, Activity, Algorithm, Pseudo Code	1. 2. 3. 4. 5. 6.	 Switch on the main and console. Switch on heater. After water attains the maximum temperature open the valve and due the water to the enclosure jackets. Wait for few minutes to attain hemispherical atmosphere. Measure the enclosure temperature using channel selector. Insert the disc with sleeve in to the slot and record the temperature. 						
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph								
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10	Graphs	, Outputs	$\mathbf{Tindeg} \qquad \mathbf{tine t in sec} \qquad$	• Stefan boltzman of the disc are not
			taken quickly (2) Comment why the shell is chosen as Hemisphere.	
12	Applica	tion Areas	Solar flat plate collector, water heating process (solar pond), ph	oto voltaic cell.
13	Remark	s		
14	Faculty with Da	Signature te		

Experiment 09 :Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Ex-changers.

-	Experiment No.:	9	Marks		Date Planned		Date Conducte d			
1	Title	Dete Heat	Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Ex-changers.							
2	Course Outcomes	Able differ	Able to determination of rate of heat transfer by LMTD and effectiveness for Jifferent flow arrangement.							
3	Aim	To d and o	To determine rate of heat transfer and overall heat transfer co-efficient in parallel and counter flow heat ex-changer.							
4	Material / Equipment Required	Heat rota	Heat ex-changer hearing inner copper tube through which water flows, heaters, rota meter, blower, channel selector and digital temperature, display.							
5	Theory, Formula, Principle, Concept	Heat exchanger is a device by which heat is transferred from one medium to another, whether the media are separated by a solid wall so that they never mix, or the media are in direct contact. They are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants,								

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	jnt⊚z017. CF		netrole	etroleum refineries, and natural gas processing. The types of heat exchangers to							
			be tes	e tested in the experiment are single-pass, parallel-flow and counter flow							
			conce	ntric tube hea	at exchang	jers. In a p	parallel-flow	heat exchai	nger, the wo	rking	
			fluids [·]	flow in the sa	ame directi	ion.In the d	counter-flow	exchanger,	the fluids flo	ow in	
			paralle	el but in oppo	osite direct	tion.The va	ariables that	affect the	performance	of a	
			heat e	at exchanger are the fluid mass flow properties, the fluid inlet temperatures, the							
			configuration, and Area and scale deposits of heat transfer surfaces.								
6	Proced	ure,	1. Allow water to circulate in inner copper tube by opening flow								
	Program, Activity, Algorithm, Pseudo		С	ontrol valve o	f the rota n	neter, mon	itor the flow	rate.			
			2. Operate the valve system to make water flow either in parallel or								
	Code		C 2	ounter flow di	rection.	tomocrati	ura indiaatar	and allow	about 10 mi	for	
			ى. ++	JW e temnera	ture to be	e temperati ecome ste	adv state i	is reached	Note down	1. 101 the	
			u te	emperature		ecome ste	auy state i	is reached.		i uie	
		4. Measure the water flow rate from the rotameters for both the								e hot	
			and cold fluid.								
			5. calculate the overall heat transfer co-efficient and effectiveness for								
			b	both parallel and counter flow arrangements.							
7	Observ	ation Table,	SI.	Hot	Water Sid	е		Cold Water	side		
	LOOK-UP Table,		No	Flow rate	T₂ in ⁰C	T₃in ⁰C	Flow rate	T ₄ in ⁰ C	T₅ in ⁰C		
	Culput			(LPM)	inlet	outlet	(LPM)	inlet	outlet		
8	Block	Circuit		Parallel F	<u>low HE</u>	1	1				
	Model	Diagram,	I	Cald Build							
	Reactio	n Equation,	T.		Temperatu	ire					
	Expecte	ed Graph				T _{io}					
			τ.	Hot fluid		Id fluid T_{co}					
				T		- Length					
				Cold fluid							
			<u>Counter Flow HE</u>								
			Cold fluid								
$\begin{array}{c c} & & & \\ \hline \\ \hline$											
			ľ,	← ←	Co	ld fluid					
			Cold fluid		> Le	ngth					

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			PARALEL AND COUNTER FLOW							
9	Sample		(1) Heat transfer rate from hot water, $Q_h = Cp(m_h) .\Delta T_{wh}$							
	Calcula	tions								
			Where,							
			Mass flow rate (m_h) = (m_h in LPM) / 60, kg/sec							
			$C_{P} = C_{Pc} = C_{Ph} = 4184 \ (\frac{3}{Kg - K})$							
			$\Delta T_{wh} = T_2 - T_3$							
			(2) Heat transfer rate from cold water, $Q_c = Cp (m_c) \Delta T_{wc}$							
			Where, Mass flow rate (m_c) = (m_c in LPM) / 60, kg/sec							
			$C_{P} = C_{Pc} = C_{Ph} = 4184 \ (\frac{J}{Kg - K})$							
			$\Delta T_{wc} = T_5 - T_4$ (3) $Q = \frac{Q_h + Q_c}{Q_h + Q_c}$							
			a, Log mean temperature difference (LIVITD)							
			$LMTD = \frac{\theta_1 - \theta_2}{\ln \frac{\theta_1}{\theta_2}}$							
			Where,							
			$\boldsymbol{\Theta}_1 = T_{hi} - T_{ci} = T_2 - T_4$							
			θ_2 = T _{ho} - T _{co} = T ₃ - T ₅							
			b) Overall Heat Transfer co-efficient (U)							

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			$U = \frac{Q}{A_s \times LMTD}, (\frac{W}{m^2 - K})$							
			Where, $A_s = \mathscr{M} \otimes \mathbb{D} d_o.L$							
			(6) Effectiveness (\Box) = $\frac{T_2 - T_3}{T_2 - T_4}$							
			(b) Counter Flow							
			(1) Heat transfer rate from hot water, $Q_h = Cp(m_h) .\Delta T_{wh}$							
			Where, Mass flow rate (m_h) = (m_h in LPM) / 60, kg/sec							
			$C_{P} = C_{Pc} = C_{Ph} = 4184 \left(\frac{J}{Kg - K}\right)$							
			$\Delta T_{wh} = T_2 - T_3$ (2) Heat transfer rate from cold water, $Q_c = Cp (m_c) \Delta T_{wc}$							
			Where, Mass flow rate (m _c) = (m _c in LPM) / 60, kg/sec							
			$C_{P} = C_{Pc} = C_{Ph} = 4184 \ (\frac{J}{Kg - K})$							
			$\Delta T_{wc} = T_4 - T_5$							
			, (3) Q = $\frac{Q_h + Q_c}{2}$							
			(4) Log mean temperature difference (LMTD)							
			$LMTD = \frac{\frac{\theta_1 - \theta_2}{\ln \frac{\theta_1}{\theta_2}}}{\ln \frac{\theta_2}{\theta_2}}$							
			Where,							
			$\boldsymbol{\Theta}_1 = T_{hi} - T_{ci} = T_2 - T_4$							
			θ_2 = T _{ho} - T _{co} = T ₃ - T ₅							
			(5) Overall Heat Transfer co-efficient (U)							

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			$U = \frac{Q}{A_s \times LMTD}$ (6) Effectiveness (\Box) = $\frac{T_2 - T_3}{T_2 - T_3}$						
10	Graphs	, Outputs	$I_2 - I_5$						
11	Poculto	& Analysia	For Parallel Flow						
	Results	& Analysis	i) The Heat transfer obtained is watts						
			ii) Overall Heat Transfer is						
			iii) Effectiveness is						
			For Counter Flow						
			1.The Heat transfer obtained is watts						
			ii) Overall Heat Transfer is						
			iii) Effectiveness is						
12	Applica	tion Areas	LMTD and NTU methods for analysis of heat exchangers.						
13	Remark	s							
14	Faculty with Da	Signature te							

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 Experiment 10: Experiments on Boiling of Liquid and Condensation of Vapour.

-	Experiment No.:	10	Marks		Date Planned		Date Conducted	
1	Title	Expe	riments on B	oiling of Liqui	d and Conde	nsation of Va	ipour.	
2	Course Outcomes	Able	to determina	tion of heat tr	ansfer coeffic	ient for Phas	e change analy	/sis.
3	Aim	To d cond	etermine the ensation and	e average he comparison	at transfer co of both.	o-efficient fo	r film wise and	1 dropwise
4	Material / Equipment Required	Gas	tube, steam ç	generator cop	per coated in	ternal tube, s	stop watch.	
5	Theory, Formula, Principle, Concept	Boile chara Whe temp porot	 Boilers and condenser which are used as heat ex-changer posses unique characteristics of heat transfer mechanism on the condensing and boiling side. When a Vapour strikes a surface temp below the corresponding saturation temperature the Vapour will immediately condense into the liquid phase. The porous of condensation may take place into two different type namely: a. Film wise condensation b. Drop wise condensation When the condensate tends to wet the surface it is called film wise condensation. When condensate does not wet the surface and when it forms droplets on the surface, it is known as drop wise condensation. 					
6	Procedure, Program, Activity, Algorithm, Pseudo Code	 (1) (2) (3) (4) (5) (6) (7) (8) (9) 	 (1) First fill the water in stainless steel tank and then switch on the main and console. (2) Switch on the supply pump starter. (3) Change the ball valve position of conducting film wise condensation experiment. (4) Switch on the heater and maintain a steady water flow, say 4LPM, through the rota meter. (5) Wait for sometime till steady steam is generated. Then the stem is passed through a separator to supply only dry stream to the cylinder. (6) The stem starts condensing on outer surface of the condenser tube and gets collected as a condensate at the bottom of the cylinder. (7) Note down the different temperatures of inlet and outlet water supply, stem pressure, flow rate of water. (8) Now change the ball valve position to drop wise condensation and conduct the experiment for same flow rate. (9) Repeat the above procedure for different flow rates and different steam 					main and ndensation M, through is passed e and gets pply, stem nd conduct rent steam
7	Observation Table, Look-up Table, Output							



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Convrio	_ ht©2017_cA	AS All rights reserve	d COURSE PLAN – CAY 2019-20 BE-5-ME	-SKIT-Ph5b1-F02-V2 2							
		no. An ngina reacive	Condensation heat transfer co-efficient = $h_{av} = \frac{Q_{steam}}{\pi dl (T_{sat} - T_s)}$	-							
			To find h_{av} using standard correlation:								
			Reynolds number for the condensate = Re = $\frac{4 \times m_{steam}}{\pi d\mu}$ =								
			If Re < 1800, Condensate flow is laminar.								
			Hence $h_{av} = \frac{1.47 \times \left[\frac{k^3 \times \rho^2 \times g}{\mu^2}\right]^{0.33}}{\text{Re}^{0.33}}$								
			$=$ ($\frac{W}{m^2 - 1}$).							
			specimen calculations for drop-wise condensation:								
			Surface temperature = $T_s =$ Pressure of steam condensing = Saturation temperature at condensing pressure = $T_{sat} =$ Inlet temperature of cooling water = $T_{wo} =$ Exit temperature of cooling water = $T_{wo} =$ Volume flow rate of cooling water = $V_w =$ Volume flow rate of condensate = V_s = Volume of steam admitter = Mass flow rate of water = $m_w = X_w V_w =$ Specific volume of condensate = $v_s = v_f$ at condensing pressure. Condensate mass flow rate = $m_{steam} = \frac{V_s}{V_c}$	_ (From tables) ed per time.							
			Heat carried away by cooling water = $Q_w = m_w \cdot C_{pw} [T_{wo} - T_{wi}]$								
			Heat given out by steam due to condensation = Q_{steam} = m_{steam} .h	fg							
			Mean film temperature = $T_m = \frac{2 - sat}{2}$								
			Properties of condensate at T_m are: $\supset \square \forall m$, h_{fg} =,	∍ k =, × =							
			Hence, Q _{steam} =								
			Condensation heat transfer co-efficient = $h_{av} = \frac{Q_{steam}}{\pi dl(T_{sat} - T_s)}$	-							
			=								

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			To find h _{av} using standard correlation for drop wise condensatio	n:
			Reynolds number for the condensate = Re = $\frac{4 \times m_{steam}}{\pi d\mu}$ =	
			If Re < 1800, Condensate flow is laminar.	
			Hence $h_{av} = \frac{1.47 \times \left[\frac{k^3 \times \rho^2 \times g}{\mu^2}\right]^{0.33}}{\text{Re}^{0.33}}$	
			$=$ ($\frac{W}{m^2}$ -	\overline{K}).
10	Graphs	, Outputs		
11	Results	& Analysis	Result:	
			Average heat transfer co-efficient for film wise condensation is _	
			Average heat transfer co-efficient for film wise condensation is _	
			 Points for Discussion : (1) List of various precautions especially that of steam g during experimentation. (2) Which is more effective among film wise and drop wise why. 	generator observed
12	Applica	tion Areas	Boiling and condensation knowledge is applicable to calculat and condensation rate in heat transfer problems.	e critical heat flux,
13	Remark	s		
14	Faculty with Da	Signature te		

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Experiment 11 : Performance Test on a Vapour Compression Refrigeration

-	Experiment No.:	11	Marks		Date Planne	d	Date Conducted	
1	Title	Perfo	rmance Test	on a Vapour	Compress	sion Refrigeratio	n	
2	Course Outcomes	Able Air –	to understan Conditioner	nd effect of h	eating and	humidification c	on a Vapour Co	mpression
3	Aim	To co perfo	onduct a test rmance.	on Vapour	Compressi	on Refrigerator	and find its co	efficient of
4	Material / Equipment Required	Refriç Evap	gerant, Comp orator.	pressor, Con	denser, Co	oling fan, Throt	tle valve, Capil	lary tube,
5	Theory, Formula, Principle, Concept	Refrig below sever refrigu refrigu syste netwo tempo tempo The p CO	Refrigeration is a process by which the temperature of a given space is reduced below that of the atmosphere or surroundings. Refrigeration can be realized by several methods, for example, Ice refrigeration, Dry ice refrigeration, Evaporative refrigeration, Air refrigeration, Vapour compression refrigeration etc. The modem refrigeration uses the vapour compression method. In this method, a closed system (the refrigerant) experiences a thermodynamic cycle ; by virtue of doing network on the system in such a cycle, it is possible to extract heat from a low temperature source (the refrigerated space) and to reject heat to a higher temperature sink (the atmosphere or cooling water). The performance of refrigerators and heat pumps is expressed in terms of the coefficient of performance (COP), defined as $COP = \frac{Desired.output}{Desired.output}$					
6	Procedure, Program, Activity, Algorithm, Pseudo Code	 (a). Switch-on the Mains and the Console. (b) Keep either the Throttle Valve or the capillary Tube open-when the capillary tube is open, the throttle valve should be closed and vice versa. Both devices have the same expansion (or throttling) effect. (c) Switch-on the motor which drives the compressor and the fan (which cools the condenser). (d) The refrigerant passes through the vapour compression cycle as mentioned earlier resulting in cooling in the evaporator chamber or freezer. (e) Wait for about 5 minutes and note the Temperatures T₁ to T₅ and Pressures P₁ and P₂. 						
7	Observation Table, Look-up Table, Output	SI.No	 Pressur upstream compress (P₁) kg/c 	re Pre n of downs sor compre m ² lb	ssure tream of essor (P ₂) /in ²	Températu	ıre (°C)	From p-h curve Enthalpy (kJ/kg)

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						Compressor	T ₁ =	h ₁ =		
						Inlet				
						Compressor	T ₂ =	h ₂ =		
						Outlet				
						Condenser	T ₃ =	h ₃ =		
						Outlet				
						Evaporator	T ₄ =	h ₄ =		
						Inlet				
	Expecte	n Equation, ed Graph								
9	Sample	tions	In a ste	ady state, the h	eat balance is give	en by,				
	Calcula		Q _L + W _{in}	= Q _H	Eq (1)					
			Q _L = He	at removed by	the evaporator fro	m the refrigera	ted syst	em,		
			= Heat gained by the refrigerant in the evaporator.							
			= h ₁	- h ₄ per Kg of re	etrigerant.	(¹) (1) (1) (1) (1) (1)				
			Q _H = He		rom the retrigeran	t in the condens	ser.			
			$= 1_2 - 1_2$	n_3 per Ky or reformed by the	angerant.	he refrigerant				
			= b _o -	- h, per Ka of re	e compressor on a	ne reingeräht.				
			h₁= Entl	halpy of the refr	rigerant at exit of t	he evaporator.				
			$h_2 = Ent$	thalpy of the ref	rigerant at exit of t	the compressor	-			
			h₃ = Ent	thalpy of the ref	rigerant at exit of	condenser.				
			h₄ = Ent	thalpy of the ref	rigerant at exit of	the throttle valv	e.			
			The val tables/ work dc panel. 1	ues of enthalpie charts using th one in the comp The co-efficient	es of the refrigeran ne measured valu ressor can be dire of performance (C	nt at different s ues of pressure ctly obtained fr COP) of the refri	tates ca es and om the igerant s	an be obtained f temperatures. energy meter in system is given	rom The the by,	

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			COP = $\frac{Q_H}{W_{in}} = \frac{h_1 - h_4}{h_2 - h_1}$ Eq. (2)	
			Where, $Q_{H=}$ Amount of heat extracted in the refrigerator	
			W _{in} = Net work done.	
10	Graphs	, Outputs		
11	Results	& Analysis	Result: The COP of the refrigerator came out to be	
			Point for discussion	
			(1) Discuss the suitability of different Compressor speed and others.(2) Can refrigerator equipment can be used as heater. If yes	s for typical duties s how it is done.
12	Applica	tion Areas	Establishing temperature distribution within building, dete calculations, ventilating and air-conditioning system.	rmining heat loss
13	Remarl	ks		
14	Faculty with Da	Signature ite		

Experiment 12 : Air Conditioning Test Rig

-	Experiment No.:	12	Marks	Date Planned		Date Conducted	
1	Title	Perfo	ormance Test	t on a Vapour Compressio	n Air – Condi	tioner	
2	Course Outcomes	Able Air –	to understar Conditioner	nd effect of heating and h	umidification o	on a Vapour Co	ompression
3	Aim	To st	udy the effec	t of Heating and humidific	ation of air co	onditioning proc	ess
4	Material / Equipment Required	Cooli	Cooling Coil, Air Heaters-2 Sets, Steam Generator, Duct				
5	Theory, Formula, Principle, Concept	The cond any a (a) T (b) H (c) A (d) A esse syste humi the dehu purifi	science of A itions irrespe air conditionir emperature umidity ir movement ir filtering, cle The simu ntial for huma em. dity are cont air condition midification cation, etc.	Air Conditioning deals with active of external atmosphing installation are: and circulation eaning and purification. Iltaneous control of thes an comfort or for any indu In any air rolled by thermodynamic ning processes involve of air. Other aspects are obtained by installing	h maintaining eric condition e factors with strial applicat conditioning processes. D cooling, hea such as air g suitable fai	g a desirable i is. The factors hin the require tion of the air c system, tempe Depending on th ating, humidific movements, ns, blowers, di	internal air involved in ed limits is onditioning rature and ne season, cation and circulation, ucting and

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			filters	
			This equipment is designed to demonstrate differe	nt air conditioning
			processes such as cooling, heating, humidification, etc. rec	uired for different
			seasons of the year	
-				
6	Proced	ure,	The purpose of the experiment is to increase the humid	and dry bulb
	Program	n, Activity,	temperature of the incoming air. Hence for this experiment the r	etrigeration system
	Algorith	im, Pseudo	should be switched off and the steam bollers and heaters H1	and H2 should be
	Code		on.After steady state is reached the following measurements are	e made and noted.
7	Observ	ation Table,		
	Look-up	b Table,		
	Output			
8	Block.	Circuit.	Steam Inlet	
-	Model	Diagram,		
	Reactio	n Equation,		
	Expecte	ed Graph		ıt
		•	Expansion	
			Valve	
			3 CC Air T_{wbl}	
			CDR Duct	
				1
			AIR CONDITION IG TEST RIG	7
			_	
			-	
			A A A A A A A A A A A A A A A A A A A	
			PART PART CIEV	
~	Come 1		T	
9	Sample	tiono	$I_{db1} = _$ $I_{wb1} = _$	
	Calcula	uons	$I_{db2} = _$ $I_{wb2} = _$	
			The velocity of air at the exit section of the duct = v_0 =	
			The velocity of all at the EXIL Section of the uncless $v_2 = v_2$	



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11	Results	& Analysis	Result: Sensible heat factor for heating and humidific	ation process is
			,	
			Points for Discussion :	
			(1) List of various precautions observed during experim	nentation.
			(2) What is dew factor.	
12	Applica	tion Areas	Establishing temperature distribution within building, dete	rmining heat loss
	••		calculations, ventilating and air-conditioning system.	C C
13	Remarl	٢S		
14	Faculty	Signature		
	with Da	ite		

Experiment 13: Experiment on Transient Conduction Heat Transfer.

-	Experiment No.:	13	Marks		Date Planned		Date Conducte d	
1	Title	Expe	eriment on Tra	ansient Cond	uction Heat T	ransfer.	I	
2	Course Outcomes	Able	to determine	temperature	distribution a	and unsteady	state heat cor	nduction
3	Aim	To o cons unde	btain tempera tant source a er transient co	ature profile f and to companditions.	or conductior are theoretic	n through a c ally predictec	ylindrical rod ł I temperature	neated by a distribution
4	Material / Equipment Required	Tran	sient heat cor	nduction set-u	up, thermoco	uples, stop wa	atch/clock.	
5	Theory, Formula, Principle, Concept	A He state chan heat Trans freez	A Heat transfer process which is time dependent is designated as an unsteady state or transient heat transfer. There are large number of situations where changes in condition result in transient temperature distribution.Unsteady state heat transfer generally occurs before steady state operating conditions.					
6	 Big of food and in near and cold treatment of metals. Procedure, Program, Activity, Algorithm, Pseudo Code Adjust the flow of water to one litres/min using rota meter. Note the readin the Ammeter and the Voltmeter. Note down the initial temperature at seven different positions, say at dista 65mm, 130mm, 195mm etc. from the heat source. Start the stopwatch and note the temperature indicated by the Thermocol at a various points recorded at 5 minutes interval. Continue to note the temperatures till constant temperature is attained. calculations are performed to obtain temperature profile and compared theoretical values obtained. Temperature profile: Theoretical temperature and experimentally obset temperature versus distance from the hot source is drawn on a graph sheet for a provide time interval. 				ant rate by readings of at distances rmocouples tained. The pared with y observed sheet for 15			





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 Experiment 14 : Determination of temperature distribution along a rectangular and circular fin subjected to heat loss through convection using Numerical approach (ANSYS/CFD package)

-	Experiment No.:	14	Marks		Date Planned		Date Conducted	
1	Title	Dete	rmination of E	Effectiveness	on a Metallic	fin.		
2	Course Outcomes	Estin	nate the effec	tive thermal r	resistance an	d efficiency ir	n pin-fin	
3	Aim	Dete subje (ANS	rmination of ected to he SYS/CFD pac	temperature eat loss th kage)	distribution rough conv	along a rec vection usin	tangular and g Numerical	circular fin approach
4	Material / Equipment Required	The whick Ther used dimn gate on th	The experimental set up consists of a blower unit having a rectangular duct inside which the pin fin is fitted. One end of the pin fin is connected to heater. Five Thermocouples are embedded on the fin surface. Blower along with the orifice is used to measure flow of air through the duct. Input to heater is given through dimmer stat and measured by voltmeter and ammeter. Air flow is controlled by the gate valve and is measured with the help of orifice meter and the manometer fitted on the heard					
5	Theory, Formula, Principle, Concept	(i) Fin betw fins, fins Com (ii) N partic effec (iii) F withc fin, It (iv) F wher tanl n	ns are extend een a surface straight fins a and pin fins presses, Rad latural conve- cles due to t t resulting fro in effectivent but is denoted b	led surfaces e and the adja and pin-fins. A are fixed to iation, Heat e ction is the h he macrosco m the density ess is the rational y, $\varepsilon = \frac{\tanh(\frac{1}{k_f})}{\sqrt{\frac{h}{k_f}}}$ is the ratio of urface of the	which are use acent fluid. Fi Angular fins a plane surfa exchanges etc neat transfer pic motion o difference ca tio of heat tra \underline{ml} \underline{A} . \underline{P} <u>heat lost from</u> fin is under	ed to increas ns are classif re fixed to cy aces. Fins an c. between a s f fluid partio aused by the ansfer with th <u>m the fin to th</u> <u>base temper</u>	e the rate of he fied into three v lindrical surface re used in I.C urface and adj cles, set up by ir temperature of he fin to the he <u>he heat that wo</u> <u>ature, it is give</u>	eat transfer iz. angular es, straight . Engines, acent fluid buoyancy difference, eat transfer
6	Procedure, Program, Activity, Algorithm, Pseudo Code	(a) N 1. Sv 2. Nc (i) Vc (ii) A (iii) T 3. Re (b) F 1. Sv 2. St 3. Nc (i) Vc	latural Conve vitch on the s ofte down the oltmeter readi immeter readi inermocouple epeat the proce vitch on the s art the blower ofte down the oltmeter readi	ction: upply and ad following read ng 'V' volts ng 'A' amps s readings (T cedure for diff ction: upply and ad r, set the mar following read ng 'V' volts	just the variated ings after readings after readings after readings the variated operation of the variated ings after readings after reading	c to obtain the aching the ste puts and tabu c to obtain the as required. aching the ste	e required heat eady state: ulate the readin e required heat eady state:	input. gs. input.



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			tanh <i>ml</i>							
			$\eta_{\text{the}} = \frac{ml}{ml}$							
			h D							
			Where, m = $\sqrt{\frac{n r}{k_{c.A}}}$							
			$\bigvee h_f \cdot A$							
			P = Perimeter of fin (πD)							
			k_{f} = thermal conductivity of pin fin = 110 ($\frac{W}{m-K}$)							
			A= Area of fin = $\frac{\pi d^2}{4}$, (d = Diameter of the pin fin, m), m ²							
			I = Length of pin fin, m To find heat transfer coefficient of fin(h)							
			2) Film temperature, $T_f = \frac{T_s + Ta}{2}$ (°C)							
			Where, T_s = Surface temperature of	the cylinder =						
			$\frac{T_2 + T_3 + T_4 + T_5 + T_6}{5} $ (K)							
			5							
			I _a = I _{1,} ambient temperature (K)							
			Properties of air at the film temperature $(T_{\rm f})$ is obtained from data book, hence							
			determine							
			Kinematic viscosity, v =Thermal conductivity, k =Prandtl number, Pr =							
			(ii) Grassoff number Gr = $\frac{g \cdot \beta \cdot \Delta T \cdot d^3}{v^2}$							
			Where,							
			β = Co-efficient of thermal expansion = $\frac{1}{(T_f + 273)}$. (K ⁻¹)	I						
			$\Delta T = T_f - T_1. (K)$							
			d = Diameter of the pin fin. (m)							
			v = Kinematic viscosity. (m^2/s) ×							
			\therefore Ra. No= Gr x Pr =							
			From heat transfer Data hand book corresponding to this v number Ra, the nusselt number(Nu) is given by $0.(7 \times (C \times 10^{-25})^{0.25})$	value of Rayleigh						
			$\frac{0.6}{\times (Gr \times Pr)^{0.23}}$	<u> </u>						
			For $10^{-1} < \text{Gr} \times \text{Pr} < 10^4$, Nu = 0.68 + $\left\{1 + \left[\frac{0.492}{\text{Pr}}\right]^{0.5625}\right\}^{0.444}$							
			For $10^4 < \text{Gr} \times \text{Pr} < 10^9$, Nu = 0.59 (Gr $\times x \text{Pr}$) ^{0.25}							

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			For $10^9 < \text{Gr} \times \text{Pr} < 10^{12}$, Nu = 0.13 (Gr x Pr) ^{0.33}	
			Hence,	
			$Nu = \frac{h.l}{k}$. Or	
			$h = \frac{Nu.k}{l}.$	
			Where, h= h _{the} = natural heat transfer co-efficient, $(\frac{W}{m^2 - K})$	
			(3) Effectiveness of Fin, $\varepsilon = \frac{\tanh(ml)}{\sqrt{\frac{h.A}{k_f.P}}}$	
10	0 Graphs, Outputs			
11	Results & AnalysisResult:- free convection $h_{the} = \eta_{exp} = \epsilon = \forced convectionh_{the} = \eta_{exp} = \epsilon = \Points for discussion:-$			=
			(1) If the readings are taken when the steady state is yet to b the accuracy of the results will be affected.(2) From the observations taken in this experiment, explain determine the thermal conductivity of the material of the fin.	e reached,how will in how would you
12	Applica	tion Areas	Buildings, Mechanical systems, Refrigeration, Spacecraft, Automotive	
13	Remark	s		
14	Faculty with Da	Signature te		