Hall Ticket No | | | | | | | | | | | Question Paper Code: AME016

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MODEL QUESTION PAPER -II

B. Tech VI Semester End Examinations (Regular), May – 2020

Regulations: IARE-R16

HEAT TRANSFER

(MECHANICAL ENGINEERING)

Time: 3 hours **Max. Marks: 70**

Answer ONE Question from each Unit All Questions Carry Equal Marks All parts of the question must be answered in one place only

UNIT – I

			CLOs	Marks
1.	a)	Derive an expression for general heat conduction equation in cylindrical co-ordinate system	CLO4	**[7M]**
	b)	The door of a cold storage plant is made from two 6mm thick glass sheets separated by a uniform air-gap of 2mm. The temperature of the air inside the room is -20^{0}C and the ambient air temperature is 30^{0}C. Assuming the heat transfer coefficient between glass and air to be 23.26 W/m^{2}K. Determine the rate of heat leaking in to the room per unit area of the door. Neglect the convection effects in the air-gap. K_{glass} = 0.75WmK ; k_{air} = 0.02W/mK	CLO5	**[7M]**
2.	a)	Enumerates the basic laws which govern the heat transfer and explain in brief with suitable examples	CLO1	**[7M]**
	b)	A plate 2 cm thick and 10 cm wide is used to heat a fluid at a 30°C. The heat generation rate inside the plate is 7×10^6 W/m^2. Determine the heat transfer coefficient to maintain the temperature of the plate below 180°C. Given k (plate) = 26 W/m °C. Neglect heat losses from the edge of the plate.	CLO3	**[7M]**

UNIT-II

3.	a)	Derive expression for critical thickness of insulation for a cylinder.	CLO6	**[7M]**
	b)	A steel pipe line (k = 50W/mK) of inner diameter (I.D) is 100mm and outer diameter (O.D) is 110mm is to be covered with two layers of Insulation, each having a thickness of 50mm. The thermal conductivity of the first insulation material is 0.06 W/mK and that of the second is 0.12 W/mK. Calculate the loss of heat per metre length of pipe and the interface temperatures between the two layers of insulation when the temperature of the inside tube surface is 250 ^{0}C	CLO6	**[7M]**

and that of the outside surface of the insulation is 50 ^{0}C

4.	a)	Describe the temperature distribution along the length of a fin for various Boundary Conditions at tip.	CLO7	**[7M]**
	b)	A standard cast iron pipe (inner diameter = 50 mm and (outer diameter = 55 mm) is insulated with 85 percent magnesium insulation (k = 0.02 W/m^{0}C). Temperature at the interface between the pipe and insulation is 300^{0}C. The allowable heat loss through the pipe is 600 W/m length of pipe and for the safety, the temperature of the outside surface of insulation must not exceed 100^{0}C. Determine i) Minimum thickness of insulation and ii) the temperature inside surface of the pipe assuming its thermal conductivity as 20 W/m^{0}C.	CLO5	**[7M]**

UNIT-III

5.	a)	Using Buckingham π dimensional analysis, derive an expression for heat transfer coefficient for a free convection. The variables involved are h (heat transfer coefficient), ρ (fluid density), D (tube diameter), μ (fluid viscosity), c_p (specific heat), k (thermal conductivity), βg Δt (β - coefficient of volume expansion of the fluid, Δt - difference of temperatures between the heated surface and the undisturbed fluid).	CLO8	**[7M]**
	b)	Estimate the heat loss from a vertical wall exposed to nitrogen at one atmospheric pressure and 4 ^{0}C. The wall is 0.2 m high and 2.5 m wide, and is maintained at 56 ^{0}C. The average Nusselt number NuH over the height of the plate for natural convection is given by NuH = 0.13(Gr. Pr) 1/3. The properties for nitrogen at a mean film temperature of (56 + 4)/2 = 30^{0}C are given as ρ= 1.142 kg/m^3, k = 0.026 W/m K, v = 15.63 × 10-6 m^2 /s, Pr = 0.713.	CLO12	**[7M]**
6.	a)	Explain the natural convection heat transfer on a Vertical hot plate with the help of velocity and temperature profiles.	CLO11	**[7M]**
	b)	Estimate the heat transfer coefficient for a laminar fully developed fluid (k=0.175W/mK) inside a 6mm inner diameter tube under uniform wall temperature boundary condition. Also compute heat transfer rate between the tube wall and the fluid for a length of 8m if the mean temp difference between the wall and the fluid is 50^{0}C.	CLO10	**[7M]**

UNIT-IV

7.	a)	Explain the different stages of boiling with neat sketch	CLO14	**[7M]**
	b)	Two parallel plates 0.5 by 1.0 m are spaced 0.5 m apart. One plate is maintained at 1000 ^{0}C and the other at 500 ^{0}C. The emissivities of the plates are 0.2 and 0.5, respectively. The plates are located in a very large room, the walls of which are maintained at 27 ^{0}C. The plates exchange heat with each other and with the room, but only the plate surfaces facing each other are to be considered in the analysis. Find the net transfer to each plate and to the room.	CLO15	**[7M]**
8	a)	Derive the expression for average heat coefficient over a vertical plate for film wise condensation.	CLO16	**[7M]**
	b)	A glass plate 30 cm square is used to view radiation from a furnace. The transmissivity of the glass is 0.5 from 0.2 to 3.5 μm. The emissivity may be assumed to be 0.3 up to 3.5 μm and 0.9 above that. The transmissivity of the glass is zero, except in the range from 0.2 to 3.5 μm. Assuming that the furnace	CLO17	**[7M]**

is a blackbody at 2000 ^{0}C, calculate the energy absorbed in the glass and the energy transmitted.

UNIT-V

9.	a)	Derive an expression for LMTD in case of a counter flow double pipe heat exchanger	CLO19	**[7M]**
	b)	A flow of 0.1kg/s of exhaust gases at 70^{0}K from a gas turbine is used to preheat the incoming air, which is at the ambient temperature of 30^{0}K. It is desired to cool the exhaust to 40^{0}K and it is estimated that an overall heat coefficient of 30W/m^{2}K can be achieved in an appropriate exchanger. Determine the area required for a counter flow heat exchanger. Take the specific heat of exhaust gasses the same as for air, Which is1000J/kg.K.	CLO19	**[7M]**
10.	a)	Derive NTU of parallel flow and counter flow heat exchangers.	CLO20	**[7M]**
	b)	3000 kg/hr of furnace oil is to be heated from 10^{0}C in a shell and tube type heat exchanger. The oil is to flow inside the tubes while steam at 120^{0}C is flowing through the shell. If the tube size is 1.9cm outer diameter and 1.65cm Inner diameter determine the number of passes, number of tubes per pass and the length of each tube.	CLO20	**[7M]**

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COURSE OBJECTIVES (COs):

I	Understand the basic modes of heat transfer like conduction, convection and radiation with and without phase change in solid liquids and gases.
II	Design and analyze thermal fluidic components in engineering systems to energy mechanisms (in the form of heat transfer) for steady and unsteady state.
III	Conduct experiments in laboratories and analyze the results with theoretical ones to evolve research oriented projects in the field of heat transfer as well as propulsion.
IV	Apply the concepts of heat transfer with convective mode in internal and external flows involved in engineering components and work in real time problems in Industry.

COURSE OUTCOMES

CO1	Understand the mechanisms of heat transfer and applying the laws to convert into mathematical model with respect to the modes and steady state process.
CO2	Derive and formulate the mathematical models for steady state heat transfer phenomenon and understand the applicability to different surfaces and geometries.
CO3	Understand the concepts of convective heat transfer and solving problems with various processes like free and forced convection.
CO4	Explore the concept of boundary layer and obtaining the derivation for empirical relations. Understanding the concept of condensation, boiling and radiation heat transfer.
CO5	Understand the concepts of different types of heat exchangers and applying LMTD and NTU methods for solving heat exchanger in real time problems.

COURSE LEARNING OUTCOMES (CLOs):

S No	Description
AME016.01	Understand basic concepts of heat transfer modes, Fourier Law and First law of thermodynamics.
AME016.02	Remember the basic laws of energy involved in the heat transfer mechanisms.
AME016.03	Understand the physical system to convert into mathematical model depending upon the mode of Heat Transfer.
AME016.04	Understand the thermal response of engineering systems for application of Heat Transfer mechanism in both steady and unsteady state problems.
AME016.05	Understand heat transfer process and systems by applying conservation of mass and energy into a system.
AME016.06	Understand the steady state condition and mathematically correlate different forms of heat transfer
AME016.07	Analyse finned surfaces, and assess how fins can enhance heat transfer
AME016.08	Remember dimensionless numbers which are used for forced and free convection phenomena.
AME016.09	Understand the applications of Buckingham Pi Theorem in deriving various non dimensional numbers and their applications in heat transfer
AME016.10	Remember and use the methodology presented in tutorial to solve a convective heat transfer problems

S No	Description
AME016.11	Understand the various forms of free and forced convection and the application of the same in day to day problems
AME016.12	Calculate local and global convective heat fluxes using Nusselt's Theory.
AME013.13	Understand the method to evolve hydrodynamic and thermal boundary layers applied mathematically to vertical plates and Tubes
AME016.14	Understand the physical mechanisms of phase change involving pool, nucleate and film boiling processes
AME016.15	Understand Nusselt's theory of condensation for the application in film and dropwise condensation
AME016.16	Correlate the empirical relations in terms of vertical and horizontal cylinders during film condensation
AME016.17	Understand the concepts of black and gray body radiation heat transfer.
AME016.18	Understand the concept of shape factor and evolve a mechanism for conducive radiation shields
AME016.19	Understand the various classifications of heat exchangers based on arrangement and correlate the effects of fouling
AME016.20	Understand the LMTD and NTU methods and apply the same for solving real time problems in heat exchangers

Mapping of Semester End Examinations to Course Learning Outcomes:

SEE Question Number		Course Learning Outcomes		Course Outcomes	Blooms Taxonomy Level
1	a	AME016.04	Understand the thermal response of engineering systems for application of Heat Transfer mechanism in both steady and unsteady state problems.	CO 1	Understand
	b	AME016.05	Understand heat transfer process and systems by applying conservation of mass and energy into a system.	CO 1	Understand
2	a	AME016.01	Understand basic concepts of heat transfer modes, Fourier Law and First law of thermodynamics.	CO 1	Understand
	b	AME016.03	Understand the physical system to convert into mathematical model depending upon the mode of Heat Transfer.	CO 1	Understand
3	a	AME016.06	Understand the steady state condition and mathematically correlate different forms of heat transfer	CO 2	Remember
	b	AME016.06	Understand the steady state condition and mathematically correlate different forms of heat transfer	CO 2	Remember
4	a	AME016.07	Analyse finned surfaces, and assess how fins can enhance heat transfer	CO 2	Remember
	b	AME016.05	Understand heat transfer process and systems by applying conservation of mass and energy into a system.	CO 2	Understand
5	a	AME016.08	Remember dimensionless numbers which are used for forced and free convection phenomena.	CO 3	Remember

	b	AME016.12	Calculate local and global convective heat fluxes using Nusselt's Theory.	CO 3	Remember
6	a	AME016.11	Understand the various forms of free and forced convection and the application of the same in day to day problems	CO 3	Understand
	b	AME016.10	Remember and use the methodology presented in tutorial to solve a convective heat transfer problems	CO 3	Remember
7	a	AME016.14	Understand the physical mechanisms of phase change involving pool, nucleate and film boiling processes	CO 4	Understand
	b	AME016.15	Understand Nusselt's theory of condensation for the application in film and dropwise condensation	CO 4	Understand
8	a	AME016.16	Correlate the empirical relations in terms of vertical and horizontal cylinders during film condensation	CO 4	Remember
	b	AME016.17	Understand the concepts of black and gray body radiation heat transfer.	CO 4	Understand
9	a	AME016.19	Understand the various classifications of heat exchangers based on arrangement and correlate the effects of fouling	CO 5	Understand
	b	AME016.19	Understand the various classifications of heat exchangers based on arrangement and correlate the effects of fouling	CO 5	Understand
10	a	AME016.20	Understand the LMTD and NTU methods and apply the same for solving real time problems in heat exchangers	CO 5	Remember
	b	AME016.20	Understand the LMTD and NTU methods and apply the same for solving real time problems in heat exchangers	CO 5	Remember

Prepared by:

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