# INSTITUTE OF AERONAUTICAL ENGINEERING (Autonomous)

Dundigal, Hyderabad - 500 043


## MECHANICAL ENGINEERING

## TUTORIAL QUESTION BANK

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| **Course Title** | **HEAT TRANSFER** | | | | |
| **Course Code** | AME016 | | | | |
| **Programme** | B.Tech | | | | |
| **Semester** | VI | ME | | | |
| **Course Type** | Core | | | | |
| **Regulation** | IARE - R16 | | | | |
| **Course Structure** | **Theory** | | | **Practical** | |
| | **Lectures** | **Tutorials** | **Credits** | **Laboratory** | **Credits** |
| | 3 | 1 | 4 | - | - |
| **Chief Coordinator** | Dr. Ch. Sandeep, Associate Professor, ME | | | | |
| **Course Faculty** | Dr. K Ch Apparao, Associate Professor, ME | | | | |

## COURSE OBJECTIVES:

| S.NO | Description |
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| 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 (Cos):

| S.NO | Description |
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| 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)

Students, who complete the course, will have demonstrated the ability to do the following:

| S. No. | Outcomes |
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| 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 |
| 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 |

| S.No | Question | Blooms Taxonomy Level | Course Outcomes (COs) | Course Learning Outcome |
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| **UNIT-I<br>INTRODUCTION TO HEAT TRANSFER, CONDUCTION** | | | | |
| **Part - A (Short Answer Questions)** | | | | |
| 1 | How does the science of heat transfer differ from the science of Thermodynamics? | Understand | CO1 | AME016.01 |
| 2 | What are the different modes of heat transfer? | Remember | CO1 | AME016.02 |
| 3 | What is heat flux? How is it related to the heat transfer rate? | Remember | CO1 | AME016.02 |
| 4 | Define Fourier's law of heat conduction? | Understand | CO1 | AME016.01 |

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| 5 | How are heat, internal energy, and thermal energy related to each other? | Remember | CO1 | AME016.03 |
| 6 | Define thermal conductivity and explain its significance in heat transfer? | Understand | CO1 | AME016.01 |
| 7 | What are the factors affecting the thermal conductivity? | Remember | CO1 | AME016.02 |
| 8 | How does heat conduction differ from convection? | Remember | CO1 | AME016.02 |
| 9 | How does forced convection differ from natural convection? | Remember | CO1 | AME016.02 |
| 10 | Which is a better heat conductor, diamond or silver? Support your answer. | Remember | CO1 | AME016.01 |
| 11 | State the laws of heat transfer? | Understand | CO1 | AME016.01 |
| 12 | What is thermal diffusivity and explain its significance? | Understand | CO1 | AME016.01 |
| 13 | Define the thermal conductance and thermal resistance of a given system? | Remember | CO1 | AME016.02 |
| 14 | Define thermal conductivity. How can it be determined experimentally? | Remember | CO1 | AME016.01 |
| 15 | Why are metals good thermal conductors, while non metals are poor conductors of heat? | Understand | CO1 | AME016.01 |
| 16 | Explain the initial and boundary conditions? | Remember | CO1 | AME016.02 |
| 17 | Write the three dimensional heat conduction equations in Cartesian coordinates? | Understand | CO1 | AME016.01 |
| 18 | What is Newton’s law of cooling? | Remember | CO1 | AME016.02 |
| 19 | Define Stefan Boltzmann Law? | Remember | CO1 | AME016.02 |
| 20 | What is meant by one dimensional heat conduction? | Remember | CO1 | AME016.02 |
| **Part - B (Long Answer Questions)** | | | | |
| 1 | Describe different types of boundary conditions applied to heat conduction problem? | Understand | CO1 | AME016.03 |
| 2 | How many boundary conditions are needed to solve a second-order differential equation of heat conduction? | Remember | CO1 | AME016.04 |
| 3 | Does any of the energy of the sun reach the earth by conduction or convection? Explain. | Remember | CO1 | AME016.05 |
| 4 | Derive general conduction equation in Cartesian coordinates and cylindrical co ordinates. | Remember | CO1 | AME016.04 |
| 5 | Draw the temperature profile for steady-state conduction through a material with constant thermal conductivity? | Understand | CO1 | AME016.04 |
| 6 | The surface temperature of the sun is approximately 5500ºC. Assuming the sun to be perfect radiator, estimate the radiation heat flux from the sun? | Understand | CO1 | AME016.05 |
| 7 | List out some examples for natural convection and forced convection? | Understand | CO1 | AME016.05 |
| 8 | Briefly explain the laws of heat transfer and give the importance in the quantitative analysis of problems? | Understand | CO1 | AME016.03 |
| 9 | Explain the concept of thermal resistance. On what parameters resistance depend upon? | Remember | CO1 | AME016.05 |
| 10 | Why metals are good thermal conductors, while non-metals are poor conductors of heat? Explain with an example. | Understand | CO1 | AME016.03 |
| 11 | Explain the concept of overall heat transfer coefficient. Represent a thermal circuit with conduction and convection. | Understand | CO1 | AME016.04 |

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| 12 | Differentiate between steady and transient heat conduction? | Remember | CO1 | AME016.03 |
| 13 | List out the special forms of the heat conduction equation? | Understand | CO1 | AME016.03 |
| 14 | Differentiate between diffusion and mass transfer? | Understand | CO1 | AME016.04 |
| 15 | Explain the heat transfer process for practical interest which involves change of phase? | Remember | CO1 | AME016.02 |
| 16 | Explain about the combined mechanism of heat transfer? | Understand | CO1 | AME016.01 |
| 17 | Write a brief note on concept of driving potential? | Remember | CO1 | AME016.02 |
| 18 | Write some of the typical values of convective heat transfer coefficients? | Understand | CO1 | AME016.02 |
| 19 | What are super conductors and explain them with examples? | Understand | CO1 | AME016.04 |
| 20 | What is thermal radiation and explain different types of thermal radiation? | Remember | CO1 | AME016.05 |
| **Part - C (Problem Solving and Critical Thinking Questions)** | | | | |
| 1 | A stainless steel plate 2cm thick is maintained at a temperature of 550ºC at one face and 50ºC on the other. The thermal conductivity of stainless steel at 300ºC is 19.1 W/mK. Compute the heat transferred through the material per unit area. | Understand | CO1 | AME016.03 |
| 2. | A flat plate of length 1m and width 0.5m is placed in an air stream at 30ºC blowing parallel to it. The convective heat transfer coefficient is 30 $W/m^2$ K. Calculate the heat transfer if the plate is maintained at a temperature of 300ºC. | Understand | CO1 | AME016.05 |
| 3 | A radiator in a domestic heating system operates at a surface temperature of 55ºC. Determine the rate at which it emits radiant heat per unit area if it behaves as a black body. | Understand | CO1 | AME016.05 |
| 4 | If the combustion chamber wall is made up of Firebrick (k=0.145W/mK,(ε=0.85)and is 1.45 cm thickness, Compute the overall heat transfer coefficient for the following data. Gas temperature $800^0$C, Wall temperature on gas side $=798^0$C, Film conductance on gas side 40W /$m^2$K, Film conductance on coolant side 10 W/$m^2$K, Radiation shape factor between wall and gas is 1. | Remember | CO1 | AME016.04 |
| 5 | An insulated pipe of 50mm outside diameter (ε=0.8) is laid in a room at 30ºC. If the surface temperature is 250ºC and the convective heat transfer coefficient is 10 W/$m^2$K, calculate the heat loss per unit length of pipe. | Remember | CO1 | AME016.04 |
| 6 | An immersion water heater of surface area 0.1$m^2$ and rating 1kW is designed to operate fully submerged in water. Estimate the surface temperature of the heater when the water is at 40ºC and the heat transfer coefficient is 300 W/ $m^2$K. If this heater is by mistake used in air at 40ºC with h=9 W/ $m^2$K, what will be its surface temperature? | Understand | CO1 | AME016.03 |
| 7 | Derive the general differential equation for heat conduction in Cartesian coordinate system with neat sketch? | Understand | CO1 | AME016.03 |
| 8 | Derive the heat conduction equation in cylindrical coordinate system with neat sketch? | Understand | CO1 | AME016.03 |
| 9 | Derive the heat conduction equation in spherical coordinate system with neat sketch? | Remember | CO1 | AME016.04 |
| 10 | Explain about the initial and boundary conditions with the different types of boundary conditions? | Understand | CO1 | AME016.05 |
| **UNIT-II**<br>**ONE DIMENSIONAL STEADY STATE AND TRANSIENT CONDUCTION HEAT** | | | | |

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| **Part - A (Short Answer Questions)** | | | | |
| 1 | Define overall heat transfer coefficient? | Understand | CO2 | AME016.06 |
| 2 | What is critical radius of insulation or critical thickness? | Understand | CO2 | AME016.06 |
| 3 | Explain about Stefan Boltzmann constant? | Understand | CO2 | AME016.05 |
| 4 | Explain about moist heating method? | Remember | CO2 | AME016.07 |
| 5 | What are extended surfaces and what is the other name for them? | Remember | CO2 | AME016.07 |
| 6 | Define fin efficiency and effectiveness? | Understand | CO2 | AME016.07 |
| 7 | What is meant by steady state heat conduction? | Remember | CO2 | AME016.06 |
| 8 | What is meant by transient heat conduction or unsteady state conduction? | Remember | CO2 | AME016.06 |
| 9 | What is a composite system? | Remember | CO2 | AME016.06 |
| 10 | Give the significance of Newtonian heating or cooling process? | Remember | CO2 | AME016.06 |
| 11 | Explain about multi-dimensional conduction? | Understand | CO2 | AME016.06 |
| 12 | Define Biot number? | Remember | CO2 | AME016.06 |
| 13 | Explain the significance of Fourier number? | Understand | CO2 | AME016.06 |
| 14 | What is non periodic heat flow? | Understand | CO2 | AME016.06 |
| 15 | What is meant by lumped heat analysis? | Remember | CO2 | AME016.06 |
| 16 | What is a semi-infinite solid? | Remember | CO2 | AME016.06 |
| 17 | What is an infinite solid? | Remember | CO2 | AME016.06 |
| 18 | What are heisler charts | Remember | CO2 | AME016.06 |
| 19 | What is critical thickness of insulation on a small diameter wire or pipe? | Understand | CO2 | AME016.06 |
| 20 | What is meant by heat balance integral? | Remember | CO2 | AME016.06 |
| **Part - B (Long Answer Questions)** | | | | |
| 1 | Derive one dimensional steady state conduction equation in case of slab | Understand | CO2 | AME016.06 |
| 2 | Define the overall heat transfer coefficient? Obtain the expression for composite wall with three layers with convective conditions over the wall. | Remember | CO2 | AME016.06 |
| 3 | Distinguish between steady state conduction and unsteady state conduction. | Remember | CO2 | AME016.06 |
| 4 | Develop an expression for temperature distribution in a slab made of single material. | Remember | CO2 | AME016.06 |
| 5 | Describe the temperature distribution along the length of a fin for four various boundary conditions at tip. | Remember | CO2 | AME016.06 |
| 6 | Explain the heat transfer analysis in composite wall. | | CO2 | AME016.06 |
| 7 | Explain briefly (i)Fin effectiveness (ii) Fin efficiency | Remember | CO2 | AME016.07 |
| 8 | Derive the expression for heat transfer in fins in case of Rectangular plate fin of uniform cross section. | Understand | CO2 | AME016.07 |
| 9 | Derive the expression for heat transfer in fins in case of insulated end. | Remember | CO2 | AME016.07 |
| 10 | Derive the equation for steady-state heat transfer through a spherical shell of inner radius $r_1$ and outer radius $r_2$ and compare the result with the solution obtained for a thick walled cylinder. | Remember | CO2 | AME016.07 |
| 11 | Derive an expression for the heat loss per square metre of the surface area for a furnace wall when the thermal conductivity varies with temperature according to the relation, $K = a + bT^2$ | Remember | CO2 | AME016.06 |
| 12 | What is critical thickness of insulation on a small diameter wire or pipe. Explain its physical significance? | Understand | CO2 | AME016.05 |
| 13 | Define Biot number and Fourier number .What is their importance in heat transfer. Explain. | Remember | CO2 | AME016.05 |

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| 14 | What are Heisler charts? Explain their significance in solving transient conduction problem. | Remember | CO2 | AME016.06 |
| 15 | Derive an expression for the heat flow rate through a hollow sphere of ID $d_1$ and OD $d_2$ whose internal and external surfaces are maintained at temperatures $T_1$ and $T_2$ respectively. The thermal conductivity varies linearly with temperature from $k_1$ at $T_1$ to $k_2$ at $T_2$. | Remember | CO2 | AME016.06 |
| 16 | "It is true that insulation is provided to reduce heat transfer rate but due to insulation heat transfer rate is not reduced always" Justify the statement analytically. | Remember | CO2 | AME016.06 |
| 17 | Enumerate steps for solving long cylinders using heisliercharts | Remember | CO2 | AME016.04 |
| 18 | Enumerate steps for heat transfer analysis in slabs using heisliercharts. | Understand | CO2 | AME016.05 |
| 19 | A Thermocouple, the junction of which can be approximated as a 1mm diameter of a gas stream. The properties of the junction are $\rho$ =8500kg/$m^3$, c=320J/kg K and k=35W/m K. The heat transfer coefficient between the junction and the gas is 210W/$m^2$K. Determine how long it will take for the thermocouple to read 99% of the initial temperature difference. | Remember | CO2 | AME016.06 |
| 20 | A Steel tube of length 20cm with internal and external diameters of10and 12cm is quenched from $500^0$ C to $30^0$C in a large reservoir of waterat$10^0$C it is less owing to a film of vapour being produced at the surface, and an effective mean value between $500^0$C and $100^0$C is 0.5Kw/$m^2$. The density of steel is 7800kg/$m^3$ and the specific heat is 0.47Kj/kg K. neglecting internal thermal resistance of the steel tube, determine the quenching time | Remember | CO2 | AME016.06 |
| **Part – C (Problem Solving and Critical Thinking Questions)** | | | | |
| 1 | A Hollow heat cylinder with $r_1$=30 mm and $r_2$=50 mm, k=15W/Mk is heated on the inner surface at a rate of 10 5 W/$m^2$ and dissipates heat by conduction from the outer surface to a fluid at $100^0$ C with h = 400 W/$m^2$K. Find the temperature inside and outside surfaces of the cylinder and also find rate of heat transfer through the wall. | Remember | CO2 | AME016.06 |
| 2 | A tube 2 cm. O.D maintained at uniform temperature of Ti is covered with insulation (k= 0.20 W/Mk) to reduce heat loss to the ambient air Tα with ha=15W/$m^2$K. Find i) the critical thickness $r_c$ of insulation (ii)the ratio of heat loss from the tube with insulation to that without insulation, (a) if the thickness of insulation is equal to $r_c$. | Remember | CO2 | AME016.05 |
| 3 | A stainless steel fin (k = 20W/Mk) having a diameter of 20 mm and a length of 0.1 m is attached to a wall at $300^0$C. The ambient temperature is $50^0$C and the heat transfer coefficient is 10 W/Mk. The fin tip is insulated. Determine (a) the rate of heat dissipation from the fin, (b) the temperature at the fin tip, (c) the rate of heat transfer from the wall area covered by the fin was not used and (d) the heat transfer rate from the same fin geometry if the stainless steel fin is replaced by a fictitious fin with infinite thermal conductivity | Remember | CO2 | AME016.05 |
| 4 | Two large steel plates at temperatures of $120^0$C and $80^0$C are separated by a steel rod 300 mm long and 25mm in diameter. The rod is welded to each plate. The space between the plates is filled with insulation, which also insulates the circumference of the rod. Because of a voltage difference between the two plates, current flows through the rod, dissipating electrical energy at a | Understand | CO2 | AME016.06 |

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| | rate of 150W. Find out the maximum temperature in the rod and the heat flux. Take k for the rod as 47W/Mk. | | | |
| 5 | A cylinder steel ingot (diameter 100mm, length 300mm, k=40W/Mk, ρ=7600kg/m$^3$ and c=600J/kg K)is to be heated in a furnace from 50$^0$C to 850$^0$C. The temperature inside the furnace is 1300$^0$C and the surface heat transfer coefficient is 100W/m$^2$ K. Calculate the time required for heating | Understand | CO2 | AAE515.06 |
| 6 | Determine the heat transfer rate from the rectangular fin of length 20cm, width 40 cm and thickness 2 cm .The tip of the fin is not insulated and the fin has a thermal conductivity of 150 W/Mk. The base temperature is 100 $^0$C and the fluid is 20 $^0$C .The heat transfer coefficient between the fin and the fluid is 30W/m$^2$K | Understand | CO2 | AME016.07 |
| 7 | A copper fin (k=396 W/Mk) 0.25 cm in diameter protrudes from a wall at 95$^0$C into ambient air at 25$^0$C.The heat transfer coefficient by free convection is equal to 10 W/m$^2$K.Calculate the heat loss if (a) The fin is infinitely long (b) The fin is 2.5 cm long and the coefficient at the end is same as around the circumference | Understand | CO2 | AME016.07 |
| 8 | A solid sphere of radius 0.5 m has an internal heat generation rate of 2x10 $^6$ W/m$^3$.If the thermal conductivity of material is 40 W/Mk and the convective heat transfer coefficient at the surface of sphere is 100W/m$^2$K. Calculate the temperatures at the outer surface and at the center. Take ambient temperature as 30$^0$C. | Understand | CO2 | AME016.07 |
| 9 | Steel ball bearing (k=50W/m K, α=1.3x10-5 m2/s) having a diameter of 40mm are heated to a temperature of 650$^0$C and then quenched in a tank of oil 55$^0$C. If the heat transfer coefficient between the ball bearings and oil is 300W/m$^2$ K, determine (a) the duration of time the bearings must remain in oil to reach a temperature of 2000C, (b) the total amount of heat removed from each bearing during this time and (c) the instantaneous heat transfer rate from the bearings when they are first immersed in oil and when they reach200$^0$C. | Understand | CO2 | AME016.07 |
| 10 | A large steel ingot, which has been uniformly heated to 750 degree Celsius, is hardened by quenching it in an oil bath that is maintained at 25 degree Celsius. What length of time is required for the temperature to reach 600 degree Celsius at a depth of 1 cm? Thermal diffusivity for the steel ingot is 1.21 * 10 -5 m$^2$/s. The ingot may be approximated as a flat plate | Understand | CO2 | AME016.07 |
| **UNIT-III<br>CONVECTION, FORCED CONVECTION** | | | | |
| **Part – A (Short Answer Questions)** | | | | |
| 1 | What is forced convection? How does it differ from natural convection? Is convection caused by winds forced or natural convection? | Understand | CO3 | AME016.10 |
| 2 | What is the physical significance of the Nusselt number? How is it defined | Understand | CO3 | AME016.12 |
| 3 | Define incompressible flow and incompressible fluid. Must the flow of a compressible fluid necessarily be treated as compressible? | Remember | CO3 | AME016.08 |
| 4 | How does turbulent flow differ from laminar flow? For which flow is the heat transfer coefficient higher? | Remember | CO3 | AME016.10 |
| 5 | What is the physical significance of the Reynolds number? How is it defined for external flow over a plate of length L? | Understand | CO3 | AME016.11 |
| 6 | What is turbulent thermal conductivity? What is it caused by? | Understand | CO3 | AME016.10 |

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| 7 | State Newton's law of cooling Is the acceleration of a fluid particle necessarily zero in steady flow? Explain. | Understand | CO3 | AME016.10 |
| 8 | What are the advantages of non-dimension alizing the convection equations? | Remember | CO3 | AME016.10 |
| 9 | How is Reynolds analogy expressed? What is the value of it? What are its limitations? | Understand | CO3 | AME016.12 |
| 10 | What is drag? What causes it? Why do we usually try to minimize it? | Remember | CO3 | AME016.10 |
| 11 | What is natural convection? How does it differ from forced convection? What force causes natural convection currents? | Remember | CO3 | AME016.10 |
| 12 | In which mode of heat transfer is the convection heat transfer Coefficient usually higher, natural convection or forced convection? Why? | Remember | CO3 | AME016.10 |
| 13 | How does the Rayleigh number differ from the Grashoff number? | Remember | CO3 | AME016.12 |
| 14 | Consider laminar natural convection from a vertical hot plate. Will the heat flux be higher at the top or at the bottom of the plate? Why? | Understand | CO3 | AME016.12 |
| 15 | Show that the volume expansion coefficient of an ideal gas is 1/T, where T is the absolute temperature. | Understand | CO3 | AME016.10 |
| 16 | Why are finned surfaces frequently used in practice? Why are the finned surfaces referred to as heat sinks in the electronics industry? | Understand | CO3 | AME016.10 |
| 17 | When is natural convection negligible and when is it not negligible in forced convection heat transfer? | Understand | CO3 | AME016.09 |
| 18 | When neither natural nor forced convection is negligible, is it correct to calculate each independently and add them to determine the total convection heat transfer? | Remember | CO3 | AME016.09 |
| 19 | Under what conditions does natural convection enhance forced convection, and under what conditions does it hurt forced convection? | Understand | CO3 | AME016.10 |
| 20 | Why heat sinks with closely packed fins are not suitable for natural convection heat transfer, although they increase the heat transfer surface area more? | Remember | CO3 | AME016.10 |
| **Part – B (Long Answer Questions)** | | | | |
| 1 | Differentiate between Newtonian and Non Newtonian fluids. Give examples. | Understand | CO3 | AME016.08 |
| 2 | What is boundary layer thickness what do you mean by laminar and turbulent boundary layers. | Remember | CO3 | AME016.09 |
| 3 | What is critical Reynolds number for flow over flat plate? Explain. | Remember | CO3 | AME016.12 |
| 4 | Define local and mean heat transfer coefficient. On what factors 'h' value depends on? | Understand | CO3 | AME016.10 |
| 5 | A metal plate 0.609m in height forms the vertical wall of an oven and is at a temperature of $171^0$C. Within the oven is air at a temperature of $93.4^0$C and the atmospheric pressure. Assuming that natural convention conditions hold near the plate, and that for this case Nu=0.548(GrPr)1/4 find the mean heat transfer coefficient and the heat taken up by air per second per meter width. For air at $132.2^0$C, take k=33.2x10-6Kw/m, μ=0.232x10-4kg/ms, cp=1.005Kj/kgK. Assume air as an ideal gas and R=0.287Kj/kgK. | Understand | CO3 | AME016.11 |
| 6 | A 0.15m outer diameter steel pipe lies 2m vertically and 8m horizontally in a large room with an ambient temperature of $30^0$C. The pipe surface is at$250^0$C and has an emissivity o f 0.60. Estimate The total rate of heat loss from the pipe to the atmosphere. | Understand | CO3 | AME016.11 |

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| 7 | A nuclear reactor with its core constructed of parallel vertical plates 2.2n high and 1.45m wide has been designed on free convention heating of liquid bismuth. The maximum possible heat dissipation from both sides of each plate. For the convention coefficient the appropriate correlation is $Nu=0.13(Gr.Pr)^{1/3}$ where the properties evaluated at the mean film temperature of $650^0C$ for bismuth are: $\rho=104kg/m^3$, cp=150.7J/kgK,k=13.02W/Mk. | Understand | CO3 | AME016.11 |
| 8 | Explain the concept of Nusselt's theory of laminar flow. | Understand | CO3 | AME016.12 |
| 9 | Explain the conditions for which Dittus-Boelter equation can be used to determine heat transfer coefficient | Remember | CO3 | AME016.12 |
| 10 | What is Rayleigh number? Discuss the nature of flow with respect to it. | Understand | CO3 | AME016.12 |
| 11 | What do you mean by hydrodynamic entry length? | Remember | CO3 | AME016.10 |
| 12 | Give the steps to find heat transfer in natural convection. | Remember | CO3 | AME016.10 |
| 13 | Air at 1atm and 30 C is forced through a horizontal 30mm diameter 0.5m Long at an average velocity of 0.25m/s. The tube wall is maintained at 1370C. Calculate (a) the heat transfer coefficient and (b) percentage error if the calculation is made strictly on the basis of laminar forced convention. | Understand | CO3 | AME016.11 |
| 14 | Engine oil at 60°C flows over the upper surface of a 5-m-long flat plate whose temperature is 20°C with a velocity of 2 m/s Determine the total drag force and the rate of heat transfer per unit width of the entire plate. | Understand | CO3 | AME016.11 |
| 15 | A square plate 0.4mx0.4m maintained at a uniform temperature of $T_w$ = 400K is suspended vertically in quiescent atmospheric air at $27^0C$. Determine (a)the boundary layer thickness at the trailing edge of the plate(i.e. at x=0.4m),(b)the average heat coefficient over the entire length by using theoretical analysis .Properties of air at 350 K are v=2.075x10- 6m2/s, Pr=0.697 and k= 0.03W/Mk. | Understand | CO3 | AME016.11 |
| 16 | A 2.2cmouterdiameter pipe is to cross a river at a 30mwide section while being completely immersed in water The average flow velocity of water is 4 m/s and the water temperature is 150C. Determine the drag force exerted on the pipe by the river. | Understand | CO3 | AME016.11 |
| 17 | Give the steps to find heat transfer in natural convection. | Understan d | CO3 | AME016.11 |
| 18 | Air at 1atm and $30^0C$ is forced through a horizontal 30mm diameter0.5m Long at an average velocity of 0.25m/s. The tube wall is maintained at $137^0C$. Calculate (a) the heat transfer coefficient and (b) percentage error if the calculation is made strictly on the basis of laminar forced convention | Understand | CO3 | AME016.11 |
| 19 | Engine oil at 60°C flows over the upper surface of a 5-m-long flat plate whose temperature is 20°C with a velocity of 2 m/s Determine the total drag force and the rate of heat transfer per unit width of the entire plate | Understan d | CO3 | AME016.11 |
| 20 | A square plate 0.4mx0.4m maintained at a uniform temperature of $T_w$= 400K is suspended vertically in quiescent atmospheric air at $27^0C$. Determine (a)the boundary layer thickness at the trailing edge of the plate(i.e. at x=0.4m),(b)the average heat coefficient over the entire length by using theoretical analysis .Properties of air at $35^0$ K are $v=2.075x10^{-6}m^2/s$,Pr=0.697 and k= 0.03W/mK. | Understand | CO3 | AME016.11 |
| **Part - C (Problem Solving and Critical Thinking Questions)** | | | | |

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| 1 | Nitrogen gas at $0^0$C is flowing over a 1. 2m long,2m wide plate maintained at $80^0$C with a velocity of 2.5m/s., ρ=1.142kg/$m^3$ ,cp=1.04kJ/kgK, v=15.63x$10^{-6}$$m^2$/s and k=0.0262W/mK. Find (a) The average coefficient and (b) the total heat transfer from the plate. | Understand | CO3 | AME016.11 |
| 2 | Water at $10^0$C flows over a flat plate (at $90^0$C) measuring 1mx1m, with a velocity of 2m/s. properties of water at $50^0$C are ρ =988.$1^0$C, v=0.556x$10^{-6}$$m^2$/s, Pr=3.54 and k=0.648W/mK. Find: (a) The length of plate over which the flow is laminar, (b) the rate of heat transfer from the entire plate. | Understand | CO3 | AME016.11 |
| 3 | Water flows through a 20mm ID at a rate of 0.01kg/s entering at$10^0$C. the tube is wrapped from outside by an electric element that produces a uniform flux of 156kW/$m^2$.If the exit temperature of water is $40^0$C, estimate (a) the Reynolds number,(b)the heat transfer coefficient, (c)the length of the pipe needed, (d)the inner tube surface temperature at exit, (e)the friction factor,(f)the pressure drop in the tube, and (g)the pumping power required if the pump efficiency is 60%. Neglect entrance effects. Properties of water at mean temperature of $25^0$C are: ρ=997kg/$m^3$, cp=4180J/kgK, ν=910x$10^{-6}$Ns/$m^2$ andk=0.608W/mK. | Understand | CO3 | AME016.11 |
| 4 | It was found during a test in which water flowed with a velocity of 2.44m/s through a tube (2.54cm inner diameter and 6.08m long), that the head lost due to friction was 1.22m of water. Estimate the surface heat transfer coefficient based on Reynolds analogy. Take ρ =998kg/$m^3$ and $c_p$=4.187kJ/kgK | Remember | CO3 | AME016.11 |
| 5 | Atmosphericpressureairat$100^0$centersa0.04mdia2mlongtubewit havelocity of 9m/s. A 1kW electric heater wound on the surface of the outer surface of the tube provides a uniform heat flux to the tube. find(a)The mass flow rate of air, (b)the exit temperature of air, and (c)the wall temperature of tube at outlet. | Remember | CO3 | AME016.11 |
| 6 | Lubricating oil (ρ=865kg/$m^3$, k=0.14W/mK and $c_p$=1.78kJ/kgK and v=9x$10^{-6}$$m^2$/s) at $60^0$C enters a 1cm dia tube with a velocity of 3.5m/s. $T_W$=$30^0$C, constant. Find The tube length required to cool the oil to$45^0$C. | Remember | CO3 | AME016.11 |
| 7 | For the flow system in which air at $27^0$C and 1atm flows over a flat plateata velocity of 3m/s, estimate the drag force exerted on the 45cm of the plate using the analogy between fluid friction and heat transfer. | Understand | CO3 | AME016.11 |
| 8 | Air at 2atm and $200^0$C is heated as it flows at a velocity of 12m/s through a tube with a diameter of 3cm. A constant heat flux condition is maintained at the wall and the wall temperature is $20^0$C above the air temperature all along the length of the tube. Calculate (a) the heat transfer per unit length of tube. Properties of air at $200^0$C are Pr=0.681, μ=2.57x$10^{-5}$kg/ms, k=0.0386W/mK and $c_p$=1.025kJ/kgK. | Understand | CO3 | AME016.13 |
| 9 | Air at 1atm, $27^0$C flow across a sphere of 0.015m diameter at a velocity of 5m/s. A heater inside the sphere maintains the surface temperature at $77^0$C. Find the rate of heat transfer from the sphere. | Remember | CO3 | AME016.11 |
| 10 | Water flows at a velocity of 12m/s in a straight tube of 60mm diameter. The tube surface temperature is maintained at $70^0$C and the flowing water is heated from the inlet temperature of $15^0$C to an outlet temperature of $45^0$C. Taking the physical properties of water at the bulk temperature of $30^0$C as | Remember | CO3 | AME016.11 |

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| | ρ=995.7kg/$m^3$, cp=4.174kJ/kgK, k=61.718x$10^{-2}$W/mK, ν=0.805x$10^{-6}$$m^2$/sand Pr=5.42, Calculate (a)the heat surface coefficient from the tube surface to the water, (b)the heat transferred and (c)the length of the tube. | | | |
| **UNIT-IV<br>HEAT TRANSFER WITH PHASE CHANGE** | | | | |
| **Part - A (Short Answer Questions)** | | | | |
| 1 | What is the difference between evaporation and boiling? | Understand | CO4 | AME016.14 |
| 2 | What is the difference between sub cooled and saturated boiling? | Understand | CO4 | AME016.14 |
| 3 | Name the different boiling regimes in the order they occur in a vertical tube during flow boiling. | Understand | CO4 | AME016.14 |
| 4 | Why drop wise condensation is preferred to film wise condensation? | Remember | CO4 | AME016.15 |
| 5 | In condensate flow, how is the wetted perimeter defined? How does wetted perimeter differ from ordinary perimeter | Understand | CO4 | AME016.15 |
| 6 | What are the differences between drop wise and film wise condensation? | Remember | CO4 | AME016.15 |
| 7 | What is condensation? How does it occur? | Remember | CO4 | AME016.15 |
| 8 | How does the presence of a non-condensable gas in a vapour influence the condensation heat transfer? | Remember | CO4 | AME016.16 |
| 9 | What are the types of condensation processes? Explain. | Remember | CO4 | AME016.15 |
| 10 | Discuss some methods of enhancing pool boiling heat transfer permanently. | Remember | CO4 | AME016.14 |
| 11 | What is an electromagnetic wave? How does it differ from a sound wave? | Understand | CO4 | AME016.14 |
| 12 | Define irradiation and radiosity. | Understand | CO4 | AME016.17 |
| 13 | What are the various radiation properties? | Remember | CO4 | AME016.17 |
| 14 | Define radiation shape factor | Understand | CO4 | AME016.18 |
| 15 | Discuss some methods of enhancing pool boiling heat transfer permanently. | Understand | CO4 | AME016.14 |
| 16 | Define the properties emissivity and absorptivity. When are these two properties equal to each other? | Remember | CO4 | AME016.17 |
| 17 | What is a gray body? How does it differ from a blackbody? What is a diffuse gray surface? | Remember | CO4 | AME016.17 |
| 18 | What does the view factor represent? When is the view factor from a surface to itself not zero? | Understand | CO4 | AME016.18 |
| 19 | What are the summation rule and the superposition rule for view factors? | Remember | CO4 | AME016.17 |
| 20 | What are the two methods used in radiation analysis? How do these two methods differ? | Remember | CO4 | AME016.17 |
| **Part – B (Long Answer Questions)** | | | | |
| 1 | What are the assumptions to be considered for analysis of laminar film condensation? | Understand | CO4 | AME016.15 |
| 2 | Why the condenser tubes are horizontal | | CO4 | AME016.15 |
| 3 | What is nucleate boiling explain | | CO4 | AME016.16 |

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| 4 | Derive the expression for condensation heat transfer. | Understand | CO4 | AME016.16 |
| 5 | Explain different regimes of boiling heat transfer phenomena. | Understand | CO4 | AME016.15 |
| 6 | Sketch the film wise condensation on a vertical wall showing film thickness, velocity and temperature profiles | Understand | CO4 | AME016.15 |
| 7 | Why the condenser tubes are horizontal? | Remember | CO4 | AME016.15 |
| 8 | What is nucleate boiling? Explain. | Understand | CO4 | AME016.16 |
| 9 | Explain the term film boiling. Write in detail about Film boiling. | Understand | CO4 | AME016.16 |
| 10 | Write the correlations for boiling heat transfer in case of nucleate boiling. | Remember | CO4 | AME016.15 |
| 11 | Differentiate between different types of condensers. | Understand | CO4 | AME016.16 |
| 12 | Write correlations for condensation heat transfer. | Understand | CO4 | AME016.16 |
| 13 | Explain what do you mean by absorptivity, reflectivity and transmissivity | Understand | CO4 | AME016.17 |
| 14 | Write expression for blackbody radiation | Understand | CO4 | AME016.17 |
| 15 | What is the Stefan-Boltzmann Law? Explain the concept of total emissive power of a surface? | Understand | CO4 | AME016.17 |
| 16 | Explain in brief the concept of a black body. | Understand | CO4 | AME016.17 |
| 17 | State the Planck's law. Write down the expression for the radiation intensity. | Remember | CO4 | AME016.18 |
| 18 | Distinguish between film wise and drop wise condensation. Which of the two does give a higher heat transfer coefficient? Why? | Remember | CO4 | AME016.16 |
| 19 | Derive expression for radiant energy between two small gray surfaces | Understand | CO4 | AME016.17 |
| 20 | Write expression for monochromatic emissive power | Remember | CO4 | AME016.18 |
| **Part - C (Problem Solving and Critical Thinking Questions)** | | | | |
| 1 | A cylindrical cement tube of radii 0.05 cm and 1.0 cm has a wire embedded into it along its axis. To maintain a steady temperature difference of 120 degree Celsius between the inner and outer surfaces, a current of 5 ampere is made to flow in the wire. Find the amount of heat generated per meter length. Take resistance of wire equal to 0.1 ohm per cm of length | Understand | CO4 | AME016.16 |
| 2 | An electric cable of aluminum (k = 240 W/ m degree) is to be insulated with rubber (k = 6 W/ square meter degree). If the cable is in air (h = 6 W/square meter degree). Find the critical radius? | Understand | CO4 | AME016.16 |
| 3 | A Vertical plate 300mm wide and 1.2m high is maintained at $7^0$C and is exposed to saturated steam at 1atm pressure. Calculate the heat transfer coefficient and the total mass of steam condensed per hour. What would be the heat coefficient if the plate is inclined at $30^0$C to the vertical? | Understand | CO4 | AME016.15 |
| 4 | Estimate the power required to boil water in a copper pan, 0.35m in diameter. The pan is maintained at $120^0$C by an electric heater. What is the evaporation rate? Estimate the critical heat flux | Remember | CO4 | AME016.16 |
| 5 | A spherical vessel of 0.5 m outside diameter is insulated with 0.2 m thickness of insulation of thermal conductivity 0.04 W/m degree. The surface temperature of the vessel is – 195 degree | Remember | CO4 | AME016.16 |

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| | Celsius and outside air is at 10 degree Celsius. Determine heat flow per $m^2$ based on inside area | | | |
| 6 | Water is to be boiled at atmospheric pressure in a mechanically polished stainless steel pan placed on top of a heating unit, The inner surface of the bottom of the pan is maintained at 108°C. If the diameter of the bottom of the pan is 30 cm, determine (a) the rate of heat transfer to the water and (b) the rate of evaporation of water | Remember | CO4 | AME016.15 |
| 7 | A black body emits radiation at $200^0$K. Calculate (i) the monochromatic emissive power at 1 µ.m wavelength,(ii) wavelength at which the emission is maintained and (iii)the maximum emissive power | Understand | CO4 | AME016.17 |
| 8 | A pipe of outside diameter 20 mm is to be insulated with asbestos which has a mean thermal conductivity of 0.1 W/m degree. The local coefficient of convective heat to the surroundings is 5 W/square meter degree. Find the critical radius of insulation for optimum heat transfer from pipe? | Understand | CO4 | AME016.14 |
| 9 | An enclosure measures 1.5mx1.7m with a height of 2m. The walls and ceiling are maintained at $250^0$C and the floor at $130^0$C. The walls and ceiling have an emissivity of 0.82 and the floor 0.7.Determine the net radiation to the floor. | Understand | CO4 | AME016.17 |
| 10 | Two black discs 1m in diameter are placed directly opposite to each A cable of 10 mm outside is to be laid in an atmosphere of 25 degree Celsius (h = 12.5 W/$m^2$ degree) and its surface temperature is likely to be 75 degree Celsius due to heat generated within it. How would the heat flow from the cable be affected if it is insulated with rubber having thermal conductivity k = 0.15 W/m degree? | Understand | CO4 | AME016.17 |
| **UNIT– V<br>HEAT EXCHANGERS** | | | | |
| **Part - A (Short Answer Questions)** | | | | |
| 1 | What is a heat exchanger? | Understand | CO5 | AME016.19 |
| 2 | Define effectiveness of heat exchanger. | Understand | CO5 | AME016.19 |
| 3 | Describe the selection criteria of heat exchanger. | Understand | CO5 | AME016.19 |
| 4 | What is the range of effectiveness of a heat exchanger? | Remember | CO5 | AME016.19 |
| 5 | What is a heat exchanger? What are its applications? | Understand | CO5 | AME016.19 |
| 6 | Discuss the advantage of NTU method over the LMTD method. | Remember | CO5 | AME016.20 |
| 7 | What is LMTD correction factor? | Remember | CO5 | AME016.19 |
| 8 | How are heat exchangers classified? | Remember | CO5 | AME016.19 |
| 9 | What is mean by open and closed heat exchanger? | Remember | CO5 | AME016.19 |
| 10 | What is meant by Regenerators? | Remember | CO5 | AME016.19 |
| 11 | What are the types of heat exchangers according flow | Understand | CO5 | AME016.19 |
| 12 | What is meant by parallel flow heat exchangers? | Understand | CO5 | AME016.19 |
| 13 | What is meant by counter flow heat exchangers? | Remember | CO5 | AME016.19 |

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| 14 | What is meant by cross flow heat exchangers? | Understand | CO5 | AME016.19 |
| 15 | What is meant by NTU? | Understand | CO5 | AME016.20 |
| 16 | What is effectiveness? | Understand | CO5 | AME016.20 |
| 17 | What is the purpose of a shell and tube heat exchanger? | Remember | CO5 | AME016.19 |
| 18 | What do you understand by mixed flow and unmixed flow? | Remember | CO5 | AME016.19 |
| 19 | What is multi pass heat exchanger? Where they are used? | Remember | CO5 | AME016.19 |
| 20 | Explain about storage type heat exchanger? What are its applications? | Remember | CO5 | AME016.19 |
| **Part - B (Long Answer Questions)** | | | | |
| 1 | Derive an expression for LMTD in case of a counter – current flow double pipe heat exchanger. | Remember | CO5 | AME016.19 |
| 2 | Derive the equation for parallel flow heat exchanger using NTU method. | Remember | CO5 | AME016.20 |
| 3 | Describe the process followed in design of a simple shell and tube heat exchanger. | Remember | CO5 | AME016.19 |
| 4 | Derive NTU of parallel flow and counter flow heat exchangers | Remember | CO5 | AME016.20 |
| 5 | Derive an expression for effectiveness of counter flow heat exchanger | Remember | CO5 | AME016.19 |
| 6 | How are heat exchangers classified? Why is a counter flow heat exchanger more efficient than a parallel flow exchanger? | Understand | CO5 | AME016.19 |
| 7 | Explain how the heat exchangers are classified. | Understand | CO5 | AME016.19 |
| 8 | Discuss the general arrangement of parallel flow, counter flow and cross flow heat exchangers? And why a counter flow heat exchanger more effective than a parallel flow exchanger? | Understand | CO5 | AME016.19 |
| 9 | Discuss the advantages of NTU method over the LMTD method of heat exchanger design. | Remember | CO5 | AME016.20 |
| 10 | Derive NTU of parallel flow and counter flow heat exchangers... | Understand | CO5 | AME016.20 |
| 11 | In the definition of effectiveness, explain why minimum heat capacity value ($C_{min}$) is used for the maximum possible rate of heat transfer. | Remember | CO5 | AME016.19 |
| 12 | Show that for parallel flow heat exchanger ε=[1-exp(-NTU(1+R)]/[1+R] | Remember | CO5 | AME016.20 |
| 13 | Show that for parallel flow heat exchanger ε=[1-exp(-NTU(1-R)]/[ 1-R exp(-NTU(1-R] | Remember | CO5 | AME016.20 |
| 14 | How are exit fluid temperature determined with the help of ε-NTU method? | Understand | CO5 | AME016.20 |
| 15 | When one of the two fluids undergoes phase change, show that the effectiveness values for both parallel flow and counter flow heat exchangers are eual and given by ε=1-exp(-NTU) | Remember | CO5 | AME016.20 |
| 16 | In an oil cooler, oil enters at $160^0$C. If the water entering at $35^0$C flows parallel to oil, the exit temperatures of oil and water are $90^0$C and $70^0$C respectively. Determine the exit temperatures of oil and water if the two fluids in opposite directions. Assuming that the flow rates of the two fluids and $U_0$ remain unaltered. What would be the minimum temperatures to which oil could be cooled in parallel flow and counter flow operations? | Understand | CO5 | AME016.19 |
| 17 | In an open heart surgery under hypothermic conditions, the patient's blood is cooled before the surgery and re warmed afterwards. It is proposed that a concentric tube counter flow | Understand | CO5 | AME016.19 |

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| | heat exchanger of length 0.5m is to be used for this purpose, with a thin-walled inner tube having a diameter of 55mm.If water at $60^0$C and 0.1kg/s is used to heat blood entering the exchanger and the heat flow rate. Take $U_0$=500W/$m^2$ K, $c_p$ of blood=3.5kJ/kg K and $c_p$ of water 4.183kJ/kgK. | | | |
| 18 | A flow of 0.1kg/s of exhaust gases at 700K from a gas turbine is used to preheat the incoming air, which is at the ambient temperature of 300K. It is desired to cool the exhaust to 400K 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/kgK. | Understand | CO5 | AME016.19 |
| 19 | After a long time in service, a counter flow oil cooler is checked to ascertain if its performance has deteriorated due to fouling. In the heat transfer surface is 3.33$m^2$ and the design value of the overall heat transfer coefficient is 930W/$m^2$K, how much has it been reduced by fouling? $C_p$ of oil as 2330J/kg K and $c_p$ of water as4174J/kgK. | Remember | CO5 | AME016.19 |
| 20 | A brass (k=111W/mK) condenser tube has a 30mm outer diameter and 2mm wall thickness. sea water enters the tube at 290K and the saturated low pressure steam condenses on the outer side of the tube. The inside and outside heat transfer coefficients are estimated to be 4000 and 8000W/$m^2$K, respectively and a fouling resistance of $10^{-4}$(W/$m^2$K) on the water side is expected. Estimate the overall heat transfer coefficient based on inside area. | Understand | CO5 | AME016.19 |
| **Part - C (Problem Solving and Critical Thinking Questions)** | | | | |
| 1 | In a Double pipe counter flow heat exchanger 10000 kg/h of oil having a specific heat of 2095 J/kgK is cooled from $80^0$C to $50^0$C by 8000 kg/h of water entering at $25^0$C. Determine the heat exchanger area for an overall heat transfer coefficient of 300 W/$m^2$K. Take Cp for water as 4180 J/kgK. | Understand | CO5 | AME016.19 |
| 2 | It is required to design a shell and tube heat exchanger for heating 9000 kg/hr of water from $15^0$ C to $88^0$ C by hot engine oil (Cp = 2.35 kJ/kg-K ) flowing through the shell of the heat exchanger . The oil makes a single pass, entering at $150^0$ C and leaving at $95^0$ C with an average heat transfer coefficient of 400 W/$m^2$ -K, the water flow through 10 thin walled tubes of 25mm diameter with each tube making 8 passes through the shell. The heat transfer efficient on the water side is 3000 W/$m^2$ -K. Find the length of the tube required for the heat exchanger. | Understand | CO5 | AME016.19 |
| 3 | In a counter flow double pipe heat exchanger, water is heated from $25^0$C to $65^0$C by oil with a specific heat of 1.45kJ/kg-K and mass flow rate of 0.9kg/s. the oil is cooled from $230^0$C to $160^0$C. If overall heat transfer coefficient is 420W/$m^2$ -K. Calculate the rate of heat transfer, mass flow rate of water and surface area of heat exchanger. | Understand | CO5 | AME016.19 |
| 4 | In a food processing plant, a brine solution is heated from $8^0$C to $14^0$C in a double pipe heat exchanger by water entering at $55^0$C and leaving at $40^0$C at the rate of 0.18kg/s. if the overall heat transfer coefficient is 800 W/$m^2$K, determine the area of heat exchanger required<br>a) For a parallel flow arrangement, and<br>b) For counter flow arrangement. Take $c_p$ for water = 4.18kJ/kgK. | Understand | CO5 | AME016.19 |

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| 5 | In a Double pipe counter flow heat exchanger 10000 kg/h of oil having a specific heat of 2095 J/kgK is cooled from $80^0$C to $50^0$C by 8000 kg/h of water entering at $25^0$C. Determine the heat exchanger area for an overall heat transfer coefficient of 300 W/$m^2$K. Take Cp for water as 4180 J/kgK. | Understand | CO5 | AME016.19 |
| 6 | After a long time in service, a counter flow oil cooler is checked to ascertain if its performance has deteriorated due to fouling. In the heat transfer surface is 3.33 m $^2$ and the design value of the overall heat transfer coefficient is 930 W/$m^2$K, how much has it been reduced by fouling? $C_p$ of oil as 2330 J/kg K and $c_p$ of water as 4174 J/kgK. | Understand | CO5 | AME016.19 |
| 7 | Calculate the heat transfer area required for a 1-1 shell and tube heat exchanger which is used to cool 55000 kg/hr of alcohol from 66 $^0$C to 40 $^0$C using 40,000 kg/hr of water entering at 5 $^0$C. U = 580 W/$m^2$K, consider a) counter flow b) parallel flow.<br>CP water = $4.18 \times 10^3$ J/kg K<br>Cp alcohol = $3.76 \times 10^3$ J/kg K | Remember | CO5 | AME016.19 |
| 8 | Hot oil with a capacity rate of 2500 W/K flows through a double pipe heat exchanger. It enters at 360°C and leaves at 300°C. Cold fluid enters at 30°C and leaves at 200°C. If the overall heat transfer coefficient is 800 W/$m^2$K, determine the heat exchanger area required for (i) Parallel flow and (ii) Counter flow. | Understand | CO5 | AME016.20 |
| 9 | Saturated steam at 100°C is condensing on the shell side of a shell-and-tube heat exchanger. The cooling water enters the tubes at 30°C and leaves at 70°C. Calculate the effective log mean temperature difference if the arrangement is (i) counter flow, (ii) parallel flow and (iii) cross flow. | Understand | CO5 | AME016.20 |
| 10 | Water enters a counter flow, double pipe heat exchanges at 15 ºC, flowing at the rate of 1300 kg/h. It is heated by oil (Cp = 2 J/kg.K) flowing at the rate of 550 kg/h from the inlet temperature of 94 ºC. For an area of 1 $m^2$ an overall heat transfer coefficient of 1075 W/$m^2$K, determine the total heat transfer and the outlet temperatures of water and oil? | Understand | CO5 | AME016.20 |
| 11 | Water at the rate of 4080kg/h is heated from $35^0$C to $75^{0C}$ by oil having a specific heat of 1900J/Kg K. The exchanger is of a counter flow double pipe design. The oil enters at $110^0$C and leaves at $75^0$C. Determine the area of the heat exchanger necessary to handle this load if the overall heat transfer coefficient is 320W/$m^2$K. | Understand | CO5 | AME016.19 |
| 12 | Hot coil having a specific heat of 2.09kJ/kgK flows through a counter flow heat exchanger at the rate of 2268kg/h with an inlet temperature of $93^0$C and an outlet temperature of $65^0$C. Cold oil having a specific heat of 1.67kJ/kg K flows in at a rate of 3600kg/h and leaves at $149^0$C.What area is required to handle this load if the overall heat transfer coefficient based on the inside area is 0.7 kW/$m^2$K. | Understand | CO5 | AME016.20 |

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