INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

DEFINITIONS AND TERMINOLOGY QUESTION BANK

Course Name	:	**HEAT TRANSFER**
Course Code	:	**AME016**
Program	:	**B.Tech**
Semester	:	**VI**
Branch	:	**Mechanical Engineering**
Section	:	**A & B**
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Course Faculty	:	**Dr. Ch. Sandeep, Associate Professor, ME**

OBJECTIVES:

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.

DEFINITIONS AND TERMINOLOGY QUESTION BANK

S. No	QUESTION	ANSWER	Blooms Level	CO	CO Code
UNIT - I					
1	What is Heat transfer?	Transmission of energy from one region to another as a result of "Temperature Gradient"	Understand	CO1	AME016.01
2	What is Heat?	The energy in transit is termed as "Heat" represented by "Q"	Understand	CO1	AME016.01
3	What are the Modes of Heat Transfer?	(1) Conduction (2) Convection (3) Radiation	Remember	CO1	AME016.01
4	Define Conduction?	Transfer of Heat from one part of a substance to another part of the substance (or) from one substance to another in physical contact whit it, with appreciable displacement of the substance.	Understand	CO1	AME016.02
5	Define a Fourier's Law of Conduction?	The rate of flow of heat through a simple homogeneous solid is directly proportional to the area measured normal to the direction of heat flow and to the temperature gradient in that direction	Understand	CO1	AME016.02

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		$Q = -A dT/dx$; Where, A is Area in m^2. dT / dx – Temperature gradient, K/m; k – Thermal conductivity, W/mK..			
6	Define Thermal conductivity? .	Thermal conductivity is defined as the ability of a substance to conduct heat. Represented by "K":Units: W/mK..	Understand	CO1	AME016.02
7	What are factors affecting the Thermal Conductivity?	a. Moisture b. Density of material c. Pressure d. Temperature e. Structure of material	Remember	CO1	AME016.03
8	What is meant by Natural Convection and Forced Convection?	It is fluid motion is produced due to change in density resulting from temperature gradients, the mode of heat transfer is said to be **free or natural convection.** If the Fluid motion is artificially created by means of an external agency like blower or Fan, the heat transfer is termed as **Forced Convection.** **$Q = hA(T_s-T_f)$** Where Q is Rate of Heat Transfer **h** – Heat Transfer Coefficient (W/m^2K). **T_s** – Fluid Temperature **T_f** – Surface Temperature	Remember	CO1	AME016.03
9	What is Newton's Law of Cooling?	The rate equation for the convective heat transfer between a surface and adjacent fluid is prescribed by Newton's Law of Cooling	Understand	CO1	AME016.02
10	Define Radiation	Radiation is the transfer of heat through space or matter by means other than conduction or convection Radiation is an Electromagnetic Wave Phenomenon It depends only on the Temperature and on the optical properties of the emitter $Q = F\sigma A€(T_1^4 - T_2^4)$ Where 'σ' is Stefan-Boltzmann Constant €: emissivity F: View Factor	Understand	CO1	AME016.02
11	Define Stefan-Boltzmann law?	It is defined as the total radiant heat energy emitted from a surface is proportional to the fourth power of its absolute temperature $Q \alpha T^4$	Understand	CO1	AME016.02
12	Define Emissivity?	Emissivity is defined as the ratio of emissive power of anybody to the	Understand	CO1	AME016.02

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		emissive power of a blackbody. For gray body emissivity varies between 0 to 1, & for black body emissivity is 1.			
13	Define a black surface	A black surface is defined by three criteria: • it absorbs all radiation that is incident on it • it emits the maximum energy possible for a given temperature and wavelength of radiation (according to Planck's law) • the radiation emitted by a blackbody is not directional (it is a diffuse emitter) A black surface is the perfect emitter and absorber of radiation. It is an idealized concept (no surface is exactly a black surface), and the characteristics of real surfaces are compared to that of an ideal black surface.	Understand	CO1	AME016.02
14	What is Steady State process?	A steady process is one which is not depend on time, that is, the rate of heat transfer does not vary with time.	Remember	CO1	AME016.03
15	What is meant by One – Dimensional Heat Conduction?	If the temperature varies only in the x-direction, then the Laplacian operator takes the form d^2T/dx^2 in all directions	Remember	CO1	AME016.03
16	Write the three dimensional heat conduction equation in Cartesian coordinates	The general three dimensional heat conduction equation in Cartesian coordinate is $\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}+\frac{\dot{q}}{k}=\frac{1}{\alpha}\cdot\frac{\partial T}{\partial \tau}$	Remember	CO1	AME016.03
17	Write the three dimensional heat conduction equation in cylindrical coordinates	The general three dimensional heat conduction equation in cylindrical coordinates is $\frac{1}{r}\frac{\partial}{\partial r}\left(kr\frac{\partial T}{\partial r}\right)+\frac{1}{r^2}\frac{\partial}{\partial \Phi}\left(k\frac{\partial T}{\partial \Phi}\right)+\frac{\partial}{\partial z}\left(k\frac{\partial T}{\partial z}\right)+q=\rho c\frac{\partial T}{\partial \tau}$	Remember	CO1	AME016.03
18	What is meant by Thermal Diffusivity?	The physical significance of thermal diffusivity is that it tells us how fast heat is propagated or it diffuses through a material during changes of temperature with time. The larger the thermal diffusivity, the shortest is the time required for the applied heat to percent deeper into the solid	Understand	CO1	AME016.02
19	What is meant by initial and boundary conditions	The set equations derived so far describe a whole class of conduction phenomena in the most general form. The temperature distribution in a	Understand	CO1	AME016.02

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		medium of given form and size can be determined by solving an appropriated equation are called boundary conditions			
		UNIT - II			
1	Define overall heat transfer coefficient.	The overall heat transfer coefficient is defined in terms of the total thermal resistance between two fluids. If there are a number of thermal resistances between the two fluids, the overall heat transfer coefficient is given by: $U = 1/\sum R$ R is the Total Thermal Resistanct	Understand	CO2	AME016.04
2	What is critical radius of insulation or critical thickness?	Addition of insulating material on a surface does not reduce the amount of heat transfer rate always. In fact under certain circumstances it actually increases the heat loss up to certain thickness of insulation. The radius of insulation for which the heat transfer is maximum is called critical radius of insulation, and the corresponding thickness is called critical thickness. $R_c = k/h$	Understand	CO2	AME016.07
3	What is the effect of change in outer radius of the hollow cylinder on the thermal resistance of conduction?	the thermal resistance of conduction increases with increase in outer radius of the hollow cylinder	Understand	CO2	AME016.07
4	Define fins or Extended surfaces.	Heat transfer by convection between a surface and fluid surroundings it can be increased by attaching to the surface thin strips of metals called fins. The surfaces used for increasing heat transfer are also called as extended surfaces	Understand	CO2	AME016.07
5	Define Fin efficiency and effectiveness.	The efficiency of a fin is defined as the ratio of actual heat transferred to the maximum possible heat transferred by the fin $\eta_{fin} = Q_{fin}/ Q_{max}$ Fin effectiveness is the ratio of heat transfer with fin to that without fin		CO2	AME016.07
6	What are the Common applications of finned surfaces	(i) Electrical motors (ii) Economizers for steam power plant (iii) Convectors for steam and cold water heating systems (iv) Cooling coils	Remember	CO2	AME016.06

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7	What is meant by Transient heat conduction or unsteady state conduction?	When there is a change in temperature of the body with time then it is said to transient or unsteady state	Understand	CO2	AME016.05
8	Explain the significance of Fourier Number	Biot number and Fourier number are two dimensionless number used in transient heat transfer. They are mainly used in transient heat transfer, where you want to find the time of cooling/heating of the object from a temperature to ambient temperature It is defined as the ratio of characteristic body dimensions to the temperature wave penetration depth in time.	Understand	CO2	AME016.08
9	What is Periodic heat flow?	In periodic heat flow, the temperature varies on a regular basis	Understand	CO2	AME016.05
10	What are Heisler charts?	A group of curves are used with unsteady-state case when Biot no. is greater than 0.1. The most cases that to be treated are 1- Infinite plate (plate where thickness is very small in comparison to other dimension). 2- Infinite cylinder (where the diameter is very small compared to length) 3- Sphere	Remember	CO2	AME016.06
11	What is meant by Lumped heat analysis?	In a Newtonian heating or cooling process the temperature throughout the solid is considered to be uniform at a given time. Such an analysis is called lumped heat capacity analysis	Understand	CO2	AME016.04
12	What is meant by periodic heat flow?	Periodic heat flow through building section is practically being used for air-conditioning applications. An effort has been made to combine the non-periodic transient heat flow due to instantaneous rise in outdoor temperature with periodic heat flow	Understand	CO2	AME016.05
13	What is meant by infinite solid?	A solid which extends itself infinitely in all directions of space is known as infinite solid. In infinite solids, the Biot number value is between 0.1 and 100	Understand	CO2	CAM016.04
14	What is mean by Semi-infinite solids?	A semi-infinite solid is an idealized body that has a single plane surface and extends to infinity in all directions In a semi-infinite solid, at any instant of time, there is always a point where the effect of heating or cooling at one of its boundaries is not felt at all. At this point the temperature remains unchanged. In semi-infinite solids, the Biot number value is ∞	Understand	CO2	AME016.04
15	Define Biot Number.	The ratio of the conductive heat resistance within the object to the	Remember	CO2	AME016.08

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		convective heat transfer resistance across the object's boundary The Biot number is given by: Bi = hL/k where h = convective heat transfer coefficient, k = thermal conductivity L = characteristic length.			
16	What is the significance o f Biot number	Biot number is used to find Lumped heat analysis, Semi infinite solids and infinite solids If Bi< 0.1 Lumped heat analysis. Bi= 0.1 < Bi< 10 025.	Remember	CO2	AME016.08
UNIT - III					
1	What is dimensional analysis?	Dimensional Analysis (also called Factor-Label Method or the Unit Factor Method) is a problem-solving method that uses the fact that any number or expression can be multiplied by one without changing its value. It is a useful technique.	Understand	CO3	AME016.10
2	How is dimensional analysis used to solve problems?	Dimensional Analysis is a problem-solving method that uses the fact that any number or expression can be multiplied by one without changing its value. It is a useful technique.	Understand	CO3	AME016.10
3	Why is dimensional analysis important?	It is very important to understand the physical nature of the problem. Then it is only about solving simple mathematical equations. Therefore the dimensional analysis is a useful method for students with weaker mathematical skills too.	Understand	CO3	AME016.10
4	State Buckingham Pi Theorem	Buckingham Pi theorem states “If there are n variables in a dimensionally homogeneous equation and if these contain m fundamental dimensions, then the variables are arranged in to (n-m) dimensionless terms. These dimensionless terms are called Pi terms”	Remember	CO3	AME016.09
5	Define Reynold’s number.	It is defined as the ratio of inertia force to viscous force. Re = Inertia force / Viscous force **Re = ρvd/v**	Remember	CO3	AME016.09
6	Define Nusselt number	Nusselt number (Nu) is the ratio of convective to conductive heat transfer across (normal to) the boundary. In this context, convection includes both advection and diffusion It is represented by Nu Nu = convective heat transfer/ conductive heat transfer Nu = hL / k	Remember	CO3	AME016.09
7	Define Prandtl number	Prandtl group is a dimensionless, defined as the ratio of momentum	Remember	CO3	AME016.09

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		diffusivity to thermal diffusivity. That is, the Prandtl number is given as: $Pr = c_p\mu/k$ Where, c_p is specific heat μ is dynamic viscosity k is thermal conductivity			
8	Define Grashof number	It is defined as the ratio of product of inertia force and buoyancy force to the square of viscous force. Gr =Inertia force x Buoyancy force / [Viscous force]2	Remember	CO3	AME016.09
9	Define Stanton number.	It is the ratio of Nusselt number to the product of Reynolds number and Prandtl number	Remember	CO3	AME016.09
10	Define boundary layer thickness	The thickness of the boundary layer has been defined as the distance from the surface at which the local velocity or temperature reaches 99% of the external velocity or temperature.	Understand	CO3	AME016.13
11	What is thermal boundary layer?	In thermal boundary layer, temperature of fluid is less than 99% of free stream temperature.	Understand	CO3	AME016.13
12	What is hydrodynamic boundary layer?	In hydrodynamic boundary layer, velocity of the fluid is less than 99% of free stream velocity	Understand	CO3	AME016.13
13	Define displacement thickness	The displacement thickness is the distance , measured perpendicular to the boundary , by which the free stream is displaced on account of formation of boundary layer.	Understand	CO3	AME016.13
14	What is forced convection?	If the fluid motion is artificially created by means of an external force like a blower or fan, that type of heat transfer is known as forced convection	Understand	CO3	AME016.13
15	What is meant by free or natural convection?	If the fluid motion is produced due to change in density resulting from temperature gradients, the mode of heat transfer is said to be natural convection.	Understand	CO3	AME016.13
16	What are the dimensionless parameters used in free and forced convection?	Reynolds number (Re) Nusselt number (Nu) Prandtl number (Pr) Grashof number(Gr)	Understand	CO3	AME016.09
17	Define boundary layer thickness	The thickness of the boundary layer has been defined as the distance from the surface at which the local velocity or temperature reaches 99% of the external velocity or temperature.	Understand	CO3	AME016.13
18	Indicate the concept or significance of boundary layer	In the boundary layer concept the flow field over a body is divided in to two regions: A thin region near the body called the boundary layer where the velocity and the temperature gradients are	Understand	CO3	AME016.13

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		large. The region outside the boundary layer where the velocity and temperature gradients are very nearly equal to their free stream velocity values			
		UNIT - IV			
1	Define Boiling	The change of phase from liquid to vapour state is known as boiling. It occurs when is heated to boiling point.	Understand	CO4	AME016.14
2	What is meant by condensation?	The change of phase from vapour to liquid state is known as condensation. A pure substance condenses at a temperature equal to its boiling point.	Understand	CO4	AME016.15
3	Give the application of boiling and condensation.	Boiling and condensation process finds wide applications as mentioned below: • Thermal and nuclear power plants • Refrigerating systems • Process of heating and cooling • Air conditioning systems	Understand	CO4	AME016.14
4	What is mean by nucleate pool boiling?	Nucleate boiling is a type of boiling that takes place when the surface temperature is hotter than the saturated fluid temperature by a certain amount but where the heat flux is below the critical heat flux. The critical heat flux is the peak on the curve between nucleate boiling and transition boiling	Understand	CO4	AME016.14
5	What is meant by pool boiling?	Pool boiling is the process in which the heating surface is submerged in a large body of stagnant liquid. The relative motion of the vapor produced and the surrounding liquid near the heating surface is due primarily to the buoyancy effect of the vapor	Understand	CO4	AME016.14
6	What are the modes of condensation?	There are three modes of condensation: Filmwise condensation Dropwise condensation Direct contact condensation	Understand	CO4	AME016.15
7	What is meant by Filmwise condensation?	The liquid condensate wets the solid surface, spreads out and forms a continuous film over the entire surface is known as film wise condensation	Understand	CO4	AME016.16
8	What is meant by dropwise condensation?	In dropwise condensation, the vapor condenses into small liquid droplets of various sizes which fall down on the surface in random fashion.	Understand	CO4	AME016.15
9	What is meant by Direct contact condensation?	It occurs when vapor is brought into contact with a cold liquid. As in jet condensers, the cooling water is sprayed on the exhaust steam and there is direct contact between the exhaust steam and cooling water.	Understand	CO4	AME016.15

S. No	QUESTION	ANSWER	Blooms Level	CO	CO Code
10	What is Nucleate boiling?	Nucleate boiling is a type of boiling that takes place when the surface temperature is hotter than the saturated fluid temperature by a certain amount but where the heat flux is below the critical heat flux.	Understand	CO4	AME016.14
11	What is the purpose of boiling?	When a liquid reaches its boiling point bubbles of gas form in it which rise into the surface and burst into the air. This process is called boiling. If the boiling liquid is heated more strongly the temperature does not rise but the liquid boils more quickly	Understand	CO4	AME016.14
12	Define Emissivity?	Emissivity is defined as the ratio of the energy radiated from a material's surface to that radiated from a blackbody (a perfect emitter) at the same temperature and wavelength and under the same viewing conditions. It is a dimensionless number between 0 (for a perfect reflector) and 1 (for a perfect emitter).	Understand	CO4	AME016.17
13	What is the units of Emissivity?	In the MKS unit system, radiative flux is given in joules per second (watts) per square meter (W/m^2). Emissivity ( ) is the ratio of a surface's ability to emit radiant energy compared with the ability of a perfect black body of the same area at the same temperature	Understand	CO4	AME016.17
14	What is meant by reflectivity?	It a measure of the ability of a surface to reflect radiation, equal to the reflectance of a layer of material sufficiently thick for the reflectance not to depend on the thickness. Symbol is ρ	Understand	CO4	AME016.17
15	What is meant by absorptivity?	Absorptivity is defined as the ratio between radiation absorbed and incident radiation. Symbol is α	Understand	CO4	AME016.18
16	State Stefan-Bolzmann law	The emissive power of a blackbody is proportional to the fourth power of absolute temperature $Q = AT^4$	Remember	CO4	AME016.18
17	State Wien's displacement law.	The Wien's law gives the relationship between temperature and wavelength corresponding to the maximum spectral emissive power of the black body at that temperature	Remember	CO4	AME016.18
18	State Kirchoff's law of radiation.	This law states that the ratio of total emissive power to the absorptivity is constant for all surfaces which are in thermal equilibrium with the surroundings	Remember	CO4	AME016.18
19	What is the difference between the Stefan Boltzmann law and Wien's law	The Stefan-Boltzmann law says that the total energy radiated from a blackbody is proportional to the fourth power of its temperature, while Wien's law is the relationship between the wavelength of maximum intensity a blackbody emits and its	Remember	CO4	AME016.18

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		temperature.			
20	What is difference between radiation and irradiation?	The word "**irradiation**" refers to the exposure of something to radiation. **Radiation** has a broad meaning, covering different cases of transferring energy, including electromagnetic radiation and nuclear radiation. Irradiation refers specifically to a process by which an object is exposed to radiation.	Understand	CO4	AME016.18
21	State Lambert's cosine law.	It states the total emissive power from a radiating plane surface in any direction is proportional to the cosine of the angle of emission	Remember	CO4	AME016.17
		UNIT - V			
1	Define heat exchanger?	A heat exchanger is a system designed to transfer heat between two fluids to control the temperature of one of the fluids. A heat exchanger could remove thermal energy from a fluid used in an air-conditioning system or add thermal energy to a system where processes require a certain temperature to work properly	Understand	CO5	AME016.19
2	What are the types of heat exchangers?	• irect contact heat exchangers • ndirect contact heat exchangers • urface heat exchangers • arallel flow heat exchangers • ounter flow heat exchangers • ross flow heat exchangers • hell and tube heat exchangers • ompact heat exchangers	Understand	CO5	AME016.19
3	What is difference between heat exchanger and condenser?	Condenser is also a heat exchanger. The main difference between these two are that in heat exchanger only heat is transferred without phase change and in condenser heat is transferred along with the phase change.	Understand	CO5	AME016.19
4	What is mean by open and COsed heat exchanger?	An open system is defined as a "system in exchange of matter with its environment, presenting import and export, building-up and breaking-down of its material components." COsed systems, on the other hand, are held to be isolated from their environment.	Understand	CO5	AME016.19
5	What is mean by Recuperators?	The is the most common type of heat exchangers in which the hot and cold fluid do not come into direct contact	Understand	CO5	AME016.19

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		with each other but are separated by a tube wall or surface			
6	What is meant by Regenerators?	In this type of heat exchangers, hot and cold fluids flow alternately through the same space	Understand	CO5	AME016.19
7	What are the types of heat exchangers according flow	A heat exchanger can have several different flow patterns. Counter flow, parallel flow, and cross flow are common heat exchanger types. A counter flow heat exchanger is the most efficient flow pattern of the three	Understand	CO5	AME016.19
8	What is meant by parallel flow heat exchangers?	In this type, hot and cold fluids move in the same direction	Understand	CO5	AME016.19
9	What is meant by counter flow heat exchangers?	In this type, hot and cold fluids move in parallel but in opposite directions	Understand	CO5	AME016.19
10	What is meant by cross flow heat exchangers?	In this type, hot and cold fluids move at right angles to each other.	Understand	CO5	AME016.19
11	What is meant by shell and tube heat exchangers?	The heat exchangers have tube walls, which allow the exchange of heat between two fluids. The overall heat transfer coefficient of the heat exchanger depends on the configuration you choose. There are different types of shell and tube heat exchangers, which are used in a variety of different applications	Understand	CO5	AME016.19
12	What is the purpose of a shell and tube heat exchanger?	In a two-phase heat exchanger, a liquid can be heated to the point that it is boiled into a gas or it may be used for the purpose of cooling a vapor so that it can then be condensed into a liquid. Such phase changes typically take place on the shell side of the shell and tube heat exchanger	Understand	CO5	AME016.19
13	What is meant by compact heat exchangers?	There are many special purpose heat exchangers called compact heat exchangers. They are generally employed when convective heat transfer coefficient associated with one of the fluids is much smaller than that associated with the other fluid	Understand	CO5	AME016.19
14	What is meant by LMTD?	Log Mean Temperature Difference or LMTD is the driving force for the amount of exchanged heat by a heat exchanger. LMTD($(\Delta T)_{m)}$ approach is quite straight forward and simple. But this approach cannot be used for the cases, where phase change occurs in the heat exchanger the total heat transfer rate in that heat exchanger is expressed as $Q = U A (\Delta T)_m$	Understand	CO5	AME016.20

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		Q – Heat duty of the heat exchanger (in watts) U – Heat transfer co-efficient (in watts/Kelvin/Meter square) A – Heat transfer area (in meter square)			
15	What is meant by fouling factor?	The fouling factor represents the theoretical resistance to heat flow due to a build-up of a layer of dirt or other fouling substance on the tube surfaces of the heat exchanger, but they are often overstated by the end user in an attempt to minimize the frequency of cleaning It is represented by "f".	Understand	CO5	AME016.20
16	What is meant by NTU?	The Number of Transfer Units (NTU) Method is used to calculate the rate of heat transfer in heat exchangers (especially counter current exchangers) when there is insufficient information to calculate the Log-Mean Temperature Difference (LMTD $NTU = UA/C_{min}$	Understand	CO5	AME016.20
17	What is effectiveness?	Effectiveness (ε), is defined as the ratio of the actual heat transfer rate to the maximum possible heat transfer rate for the given flow and temperature conditions $\varepsilon = Q/Q_{max}$	Understand	CO5	AME016.20
18	What advantage does the effectiveness NTU method have over the LMTD method?	The effectiveness-NTU and LMTD methods are equivalent. An advantage of the effectiveness-NTU method is its ability to predict the outlet temperatures without resorting to a numerical iterative solution of a system of nonlinear equations	Understand	CO5	AME016.20

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