Hall Ticket Number:

Code No. : 15551 N/O

VASAVI COLLEGE OF ENGINEERING *(AUTONOMOUS)*, HYDERABAD

Accredited by NAAC with A++ Grade

B.E. (Mech. Engg.) V-Semester Main & Backlog Examinations, Jan./Feb.-2024

Heat Transfer

Time: **3 hours** Max. Marks: **60**

Note: [1] Answer **ALL** questions from **Part-A** and **ANY FIVE** from **Part-B**.
[2] Use of "**Heat and Mass Transfer Data Book [S I Units]**" is permissible.

Part-A (10 × 2 = 20 Marks)

Q. No.	Stem of the question	M	L	CO	PO
1.	Provide two examples for "pump driven forced convection" and two examples for "fan or blower driven forced convection".	2	2	1	1
2.	Current in "electricity transfer" is analogous to _____ in "heat transfer", while potential difference in "electricity transfer" is analogous to ______ in "heat transfer".	2	2	1	1
3.	Arrange four "identical fins", made of Stainless Steel, Aluminum, Silver and Brass, for an "electronic gadget" to increase heat transfer in the ascending order of your preference.	2	2	2	1
4.	Define "Biot Number [Bi]" and "Fourier Number [Fo]" as referred to transient conduction.	2	1	2	1
5.	Select FOUR fluids out of the following list, which have the velocity boundary layer thicker than the thermal boundary layer: Nitrogen, Water, Ethylene Glycol, Air, Liquid Sodium, Glycerin, Liquid Potassium and Castor Oil.	2	2	3	1
6.	Define "hydrodynamic boundary layer" and "thermal boundary layer" as referred to forced convection past an isothermal flat plate.	2	1	3	1
7.	Define direct-contact type heat exchangers and indirect-contact type heat exchangers suggesting at least one example for each.	2	1	4	1
8.	What does "critical heat flux point" in the pool boiling curve mean? What is its value for water?	2	2	4	1
9.	State the Max Planck's Distribution Law for Spectral Emissive Power of a Black Body. What is its advantage over the other two governing laws available for the same purpose.	2	1	5	1
10.	Define "Self-View Factor [F_{ii}]". Give one example where it is zero and another example where it is non-zero.	2	2	5	1

Contd... 2

	Part-B (5 × 8 = 40 Marks)				
11. a)	Derive an expression, in non-dimensional form, for steady-state radial temperature distribution in a "long hollow cylinder" without heat generation subjected to known temperatures on its inner and outer surfaces.	4	3	1	1, 2
b)	A steel tube [k = 43.26 W/m K] of 5.08 cm inside diameter and 7.62 cm outside diameter is covered with a 2.54 cm thick layer of asbestos insulation [k = 0.208 W/m K]. The inside surface of the tube receives heat by convection from hot gases at 316°C with a heat transfer coefficient 284 W/m^2 K. The outer surface of insulation is in contact with air at 38°C with a convection heat transfer coefficient 17 W/m^2 K. Calculate the rate of heat loss to air if the tube length is 3 m.	4	4	1	1, 2
12. a)	A 1.6 mm diameter steel fin [k = 16.3 W/m K] protrudes from an object maintained at 49°C. The fin is 12.5 mm long and it is exposed to an environment at 25°C that offers a convection heat transfer coefficient 570 W/m^2 K. Calculate (i) fin tip temperature, (ii) rate of heat dissipation from the fin.	4	4	2	1, 2
b)	A cylindrical bar [D = 10 cm, k = 50 W/m K and $\alpha = 2\times10^{-5}$ m^2/s] is heated in a furnace to a temperature 200°C. It is then suddenly dipped in an oil tank at 40°C that offers a surface heat transfer coefficient 150 W/m^2 K. Calculate (i) time needed to cool the centre of the bar to 50°C and (ii) temperature of the bar surface at this instant of time.	4	4	2	1, 2
13. a)	Define (i) Prandtl number and (ii) Nusselt number. What is the physical significance of each of them?	4	2	3	1, 2
b)	An iron block, modeled as a vertical cylinder and at a temperature 0°C, is in an apparently quiescent (stationary) air at 30°C. The iron block is 0.8 m in diameter and 1.2 m in height. Find the rate of convection heat transfer from the quiescent air to the iron block.	4	4	3	1, 2
14. a)	Define (i) Pool Boiling, (ii) Flow Boiling, (iii) Local Boiling and (iv) Bulk Boiling.	4	2	4	1, 2
b)	A counter-flow heat exchanger serving as an oil cooler is being designed to cool 2000 kg/h of an oil of specific heat 2.5 kJ/kg K from 105°C to 30°C making use of water that enters the heat exchanger at a temperature 15°C. The overall heat transfer coefficient is 1.5 kW/m^2 K. Calculate (i) mass flow rate of water, (ii) effectiveness of the heat exchanger and (iii) surface area needed. The exit temperature of water is 80°C. Solve the problem using Effectiveness (ε) - NTU method.	4	4	4	1, 2

		M	L	CO	PO
15. a)	Define (i) White Body, (ii) Opaque Body, (iii) Transparent Body and (iv) Black Body together with one pertinent example for each.	4	2	5	1, 2
b)	Two plates, shaped like squares, each of side 2 m, are 4 m apart. The temperatures of the two plates are, respectively, equal to 727°C and 127°C. The hotter plate has an emissivity 0.4, while the cooler plate has an emissivity 0.2. Calculate net rate of radiation heat transfer between the two plates.	4	4	5	1, 2
16. a)	Heat is generated uniformly in a stainless steel plate [k = 19.1 W/m K] of thickness 1 cm at a rate of 500 MW/m^3. The two boundaries of the plate are held at prescribed temperatures 100°C and 200°C, respectively. Calculate the steady-state temperature at the central plane of the plate.	4	4	1	1, 2
b)	Define "Fin Efficiency" and "Fin Effectiveness". Arrive at the expressions for these two parameters for the case of "Finitely Long Fin with Adiabatic Tip".	4	2	2	1, 2
17.	Answer any ***two*** of the following:				
a)	Water at 50°C enters a tube of 1.5 cm diameter and 3 m in length at a mean velocity of 1 m/s. The tube wall is maintained at a temperature 90°C, while the exit water temperature is 64°C. Calculate (i) the mean convection heat transfer coefficient and (ii) the net rate of convection heat transfer.	4	4	3	1, 2
b)	Together with a neat sketch, explain all the salient features of "Nukiyama's Pool Boiling Curve".	4	2	4	1, 2
c)	Define Total Emissive Power (E) and Emissivity (ε). Distinguish between Black Body, Gray Body and Real Body in the context of "emissivity".	4	2	5	1, 2

M : Marks; L: Bloom's Taxonomy Level; CO; Course Outcome; PO: Programme Outcome

i)	Blooms Taxonomy Level – 1	10%
ii)	Blooms Taxonomy Level – 2	45%
iii)	Blooms Taxonomy Level – 3 & 4	45%

*****