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GUJARAT TECHNOLOGICAL UNIVERSITY

BE- SEMESTER–VII (NEW) EXAMINATION – WINTER 2020

Subject Code:2171911 **Date:19/01/2021**

Subject Name:Advance Heat Transfer

Time:10:30 AM TO 12:30 PM **Total Marks: 56**

Instructions:

1. **Attempt any FOUR questions out of EIGHT questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

			MARKS
Q.1	**(a)**	Define fin effectiveness and the fin efficiency	**03**
	(b)	Define Biot number. Discuss physical significance of Biot number.	**04**
	(c)	A diecast component has a mass of 1.2 kg and density 7150 kg/m^3 with surface area of 0.075 m^2. The thermal conductivity of the material is 95 W/mK and the specific heat is 385 J/kg K. It comes out of the machine at 345°C and is exposed to air at 20°C with a convective heat transfer coefficient of 56.8 W/m^2K. Determine i. The temperature of the part after 5 minutes. ii. The time required to reach 50°C. iii. The time constant. iv. The value of convective heat transfer coefficient upto which the lumped parameter model can be used. v. The volume/area ratio upto which the lumped parameter model can be used.	**07**
Q.2	**(a)**	Define: Nusselt Number, Reynolds Number, Prandtl Number	**03**
	(b)	Differentiate nucleate boiling and film boiling.	**04**
	(c)	Derive temperature distribution and heat transfer rate expression, under one dimensional steady state, uniform volumetric heat generation rate in plane wall having same temperature at both end surface. (Assume constant cross sectional area and constant thermal conductivity.)	**07**
Q.3	**(a)**	Define: Grashof number. Tell physical significance of Grashof number.	**03**
	(b)	Express conventional generalised basic equation for forced convection parallel flow over a flat plate for local and average skin friction heat transfer convection coefficient using Nusselt Number, Reynolds Number, Prandtl Number.	**04**
	(c)	Derive differential equation, under one dimensional steady state heat conduction in straight infinite long fin of rectangular profile for following cases: i. Pure convection heat transfer through fin surface. ii. Pure radiation heat transfer through fin surface. iii. Convection and radiation heat transfer through fin surface. (Assume constant cross sectional area and constant thermal conductivity.)	**07**
Q.4	**(a)**	Tell physical significance of Nusselt number and Prandtl number.	**03**
	(b)	Explain radial fins of rectangular and parabolic profiles.	**04**
	(c)	State governing equation and boundary condition for 1-D flow for transient heat conduction in semi-infinite solids.	**07**

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A steel ingot (large in size) heated uniformly to 745°C is hardened by quenching it in an oil bath maintained at 20°C. Determine the length of time required for the temperature to reach 595°C at the depth of 12 mm. The ingot may be approximated as a flat plate. For steel ingot, thermal diffusivity = 1.2 x 10^{-5} m^2/s.

Q.5 **(a)** Define emissivity correction factor and pressure correction factor. Express equation for gas and gas mixture which correlate both above factor. **03**

(b) Distinguish between natural and forced convection heat transfer. **04**

(c) A long 10-cm-diameter steam pipe whose external surface temperature is 110°C passes through some open area that is not protected against the winds (Fig. 2). Determine the rate of heat loss from the pipe per unit of its length when the air is at 1 atm pressure and 10°C and the wind is blowing across the pipe at a velocity of 8 m/s. **07**

Assumptions: 1 Steady operating condition exists. 2 Radiation effects are negligible. 3 Air is an ideal gas.

The Nusselt number can be determined from

$$Nu = 0.3 + \frac{0.62\, Re^{1/2}\, Pr^{1/3}}{\left[1+(0.4/Pr)^{2/3}\right]^{1/4}}\left[1+\left(\frac{Re}{282000}\right)^{5/8}\right]^{4/5}$$

The properties of air at the average film temperature of $T_f = (T_s + T_\infty)/2 = (110 + 10)/2 = 60$°C and 1 atm pressure are
$k = 0.02808$ W/m · °C, Pr = 0.7202, $\nu = 1.896 \times 10^{-5}$ m^2/s.

Q.6 **(a)** Define terms: **03**

i. Spectral Transmissivity
ii. Spectral absorptivity
iii. Spectral emissivity

(b) Differentiate film wise condensation and drop wise condensation. **04**

(c) A volume of 5 cm^3 is available for a circular pin fin. Determine the optimum diameter. Conductivity = 200 W/mK, convection coefficient = 200 W/m^2K. Assume fin end is insulated. **07**

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Q.7 **(a)** State types of heat loss from human body. **03**

(b) Saturated steam at atmospheric pressure condenses on a 2-m-high and 3-m wide vertical plate that is maintained at 80°C by circulating cooling water through the other side. When plate is vertical, then the condensation heat transfer coefficient is 5848 $W/m^2\ {}^0C$. Determine the rate of heat transfer by condensation to the plate if the plate were tilted 30° from the vertical, as shown in Figure 3. **04**

(c) Fluid motion over a vertical flat plate is steady, laminar, two-dimensional and the fluid to be Newtonian with constant properties. Prove that governing equation for natural convection flow is **07**

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = \nu\frac{\partial^2 u}{\partial y^2} + g\beta(T - T_\infty).$$

Draw velocity and temperature profiles for natural convection flow over a hot vertical plate at temperature T_s inserted in a fluid at temperature T_∞.

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(Hint: Apply newton's second law of motion in x direction, momentum principle in x direction)

Q.8 **(a)** State assumption used in Nusselt theory, laminar film condensation over vertical plate. **03**

(b) Explain radiation effect on temperature measurements. Derive expression for actual temperature of fluid. **04**

(c) Define boiling. Explain various regimes of boiling. **07**

z	*erf* (*z*)	*z*	*erf* (*z*)
0.00	0.0000	0.40	0.4284
0.02	0.0225	0.42	0.4475
0.04	0.0451	0.44	0.4662
0.06	0.0676	0.46	0.4847
0.08	0.0901	0.48	0.5027
0.10	0.1125	0.50	0.5205
0.12	0.1348	0.55	0.5633
0.14	0.1569	0.60	0.6039
0.16	0.1709	0.65	0.6420
0.18	0.2009	0.70	0.6778
0.20	0.2227	0.75	0.7112
0.22	0.2443	0.80	0.7421
0.24	0.2657	0.85	0.7707
0.26	0.2869	0.90	0.7970
0.28	0.3079	0.95	0.8270
0.30	0.3286	1.0	0.8427
0.32	0.3491	1.05	0.8614
0.34	0.3694	1.10	0.8802
0.36	0.3893	1.15	0.8952
0.38	0.4090	1.20	0.9103

Fig. 1, Q-4 (c)

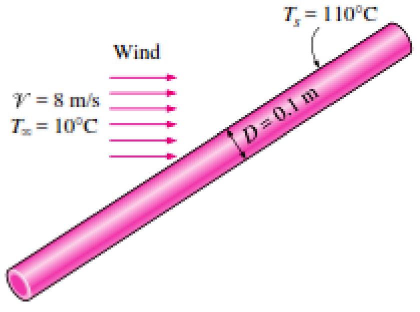

Fig. 2, Q-5(c)

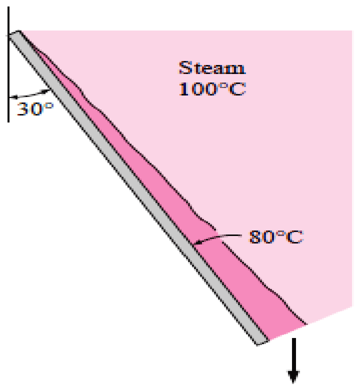

Fig. 3, Q-7 (b)