Mansoura University **Faculty of Engineering** **Program of Biomedical Engineering.** **Course Title: Heat and Mass Transfer** **Course Code: MPE 271**		**Level: 200** **Exam Type: Final** **Date: 16 November 2016** **Time: 1 Hour** **Full Mark: 20**

QUESTION NO. One:

(a) Pick up the most appropriate statement of the multiple-choice answers .

1. Heat conducted through unit area and unit thick face per unit time when temperature difference between opposite faces is unity, is called

(a) thermal resistance (b) thermal diffusivity (c) temperature gradient
(d) thermal conductivity (e) heat-transfer.

2. The value of the critical radius of insulation r_0 for a cylinder is

(a) k/h (b) $2h/k$ (c) $2k/h$ (d) None of these

3. The ratio of heat flow Q_1/Q_2 from two walls of same thickness having their thermal conductivities as $k_1 = 2\ k_2$ will be

(a) 1 (b) 0.5 (c) 2 (d) 0.25 (e) 4.

4. Emissivity of a white polished body in comparison to a black body is

(a) higher (b) lower (c) same
(d) depends upon the shape of the body (e) none of the above.

5. The heat dissipation from an finite fin and loosing heat at the tip is given by:

(a) $\sqrt{hPkA}(t_o - t_\infty)$ (b) $\sqrt{hPkA}(t_o - t_\infty)\tanh ml$

(c) $\sqrt{hPkA}(t_o - t_\infty)\dfrac{\tanh ml + (h/mk)}{1+(h/km)\tanh ml}$ (d) $\sqrt{hPkA}(t_o - t_\infty)\dfrac{\tanh ml + (h/k)m}{1+(h/km)\tanh ml}$

6. The vertical walls of a boiler furnace of size 4 m by 3 m by 3 m high. The walls are constructed from an inner fire brick wall 25 cm thick of thermal conductivity 0.4 W/m K, a layer of ceramic blanket insulation of thermal conductivity 0.2 W/m K and 8 cm thick, and a steel protective layer of thermal conductivity 55 W/m K and 2 mm thick. The inside temperature of the fire brick layer was measured at 600 °C and the temperature of the outside of the insulation 60 °C. The rate of heat loss may be :

(a) Q = 6320.96 W (b) Q = 9320.96 W (c) Q = 6020.96 W (d) Q = 6300 W

(b) A steam pipe with *I D* and *OD* as 100 and 170 *mm* is covered with two layers of insulation, 30 *mm* and 50 *mm* thick. Thermal conductivities of the insulating materials are 0.175 and 0.093 *W/m K* respectively while that of steel is 50 *W/m K*. The inner surface of the pipe is at 300 °*C* while the outer layer surface is at 50°*C*. Determine the heat loss from the pipe and the layer contact temperatures.

Question (2)

a) Starting with energy balance on a rectangular volume element derive the Poisson Equation. (Use neat sketches)

b) Atmospheric air at $t_\infty = 40°C$ with a free-stream velocity $u_\infty = 8\ m/s$ flows along a flat plate $L = 5\ m$ long and width of $2\ m$ which is maintained at a uniform temperature of $100°C$. The average drag coefficient C_m is 2.13×10^{-3}. Calculate the drag force over the entire length of the plate and the total heat transfer rate Q from the plate to the air .

The physical properties of atmospheric air at $t_f = (t_w + t_\infty)/2 = (100 + 40)/2 = 70°C$ *are:*

$$k = 0.0295\ W/(m.°C),\ v = 2.005 \times 10^{-5}\ m^2/s,\quad Pr = 0.699$$

$$Nu_m = 0.036\,\mathrm{Pr}^{0.34}\left(\mathrm{Re}_L^{0.8} - 9200\right)$$

Good Luck

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Midterm Model Answer

16 November 2016

Question No. one

(a)

(1) → (d)

(2) → (a)

(3) → (c)

(4) → (b)

(5) → (c)

(6) → (a)

1b)

Given: $r_1 = 50$ mm

$r_2 = 85$ mm

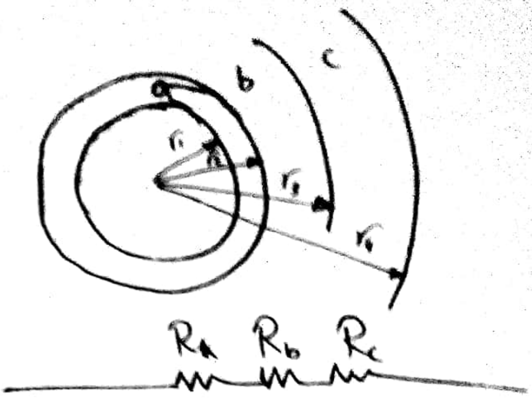
$r_3 = 115$ mm

$r_4 = 165$ mm

$K_a = 50$ W/m.K

$K_b = 0.175$ W/m.K

$K_c = 0.093$ W/m.K



$t_1 = 300$ °C

$t_4 = 50$ °C

$$R_{total} = R_a + R_b + R_c$$

$$= \frac{\ln(85/50)}{2\pi * 50} + \frac{\ln(115/85)}{2\pi * 0.175} + \frac{\ln(165/115)}{2\pi * 0.093}$$

$$= 1.69 * 10^{-3} + 0.275 + 0.618 = 0.895$$

$$Q = \frac{t_1 - t_4}{R_{total}} = \frac{300 - 50}{0.895} = 279.4 \text{ W/m}$$

$$t_2 = t_1 - QR_a = 300 - 279.4 * 1.69 * 10^{-3} = 299.5 \text{ °C}$$

$$t_3 = t_4 + QR_c = 50 + 279.4 * 0.618 = 222.67 \text{ °C}$$

uestion (2)

a) as mentioned at the source.

b)

$$\rho = \frac{P}{RT} = \frac{101325}{287 * 343} = 1.03 \ Kg/m^3$$

$$F = wLC_m \frac{\rho u^2}{2}$$
$$= 2 * 5 * 2.13 * 10^{-3} * \frac{1.03 * 8^2}{2} = 0.702 \ N$$

$$Re = \frac{uL}{\nu} = \frac{8 * 5}{2.005 * 10^{-5}} = 1995012.5$$

$$Nu = 0.036 * 0.699^{0.34}(1995012.5^{0.8} - 9200) = 3201.2$$

$$h = \frac{Nu * K}{L} = \frac{3201.2 * 0.0295}{5} = 18.89 \ W/m^2.K$$

$$Q = wLh(t_w - t_\infty)$$
$$= 2 * 5 * 18.89 \ (100 - 40) = 11332.4 \ W$$
$$= 11.33 \ KW$$