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:25th August 2019 Time: 2 Hours Full Mark: 50

Question (1) **[15 Marks]**

(a) Define the following :

Thermal conductivity, Thermal diffusivity, Nusselt number, Prandtl number, Reynolds number and Grashof number.

Q.1.b Write short notes on **(Use neat sketches).**

a. Analogy between Heat and Mass transfer.

b. Different types of fins and its influence on heat transfer.

c. Types of Heat Exchangers.

d. Thermal radiation.

e. Black body radiation

f. Absorptivity, Reflectivity, Transmissivty and Opaque body.

Question (2) **[20 Marks]**

(a) The hot combustion gases of a furnace are separated from the ambient air and its surrounding, which are at 300K, by a brick wall 15-cm thick. If the thermal conductivity of the brick is 1.25 W/m. K and a surface emissivity of 0.8. Under steady state conditions an outer surface temperature of 102 °C is measured. Free convection heat transfer to the air adjoining this surface is characterized by a convection coefficient h=20 W/m².K. Determine the inner surface temperature?

(b) A 0.9 m long, 5 cm diameter cylinder placed in an atmosphere of 40°C is provided with 10 longitudinal straight fins (k = 75 W/m.K) 0.75 mm thick. The fins protrude 2.5cm from the cylinder surface. The heat transfer coefficient from the cylinder and fins to the ambient air is 23.3 W/m^2.K. Calculate:

i. The rate of heat transfer if the surface temperature of the cylinder is 150°C.
ii. Percentage increase in heat dissipation due to fins.
iii. The fin temperature at a distance of 1.5 cm from the cylinder.

(c) Engine oil at 80°C flows over a 6 m long flat plate whose temperature is 30°C with a velocity of 3 m/s. Determine the total drag force and the rate of heat transfer over the entire plate per unit width.

The properties of engine oil are

$\rho = 867$ kg/m^3 $\quad \upsilon = 123 \times 10^{-6}$ m^2/s

$k = 0.141$ W/m. °C $\quad$ Pr $= 1505$

The average Nusselt number relations for flow over a flat plate are:

Laminar: $\quad \mathrm{Nu} = \dfrac{hL}{k} = 0.664\,\mathrm{Re}_L^{0.5}\,\mathrm{Pr}^{1/3} \qquad \mathrm{Re}_L < 5 \times 10^5$

Turbulent:

$$\mathrm{Nu} = \frac{hL}{k} = 0.037\,\mathrm{Re}_L^{0.8}\,\mathrm{Pr}^{1/3} \qquad \begin{matrix} 0.6 \le \mathrm{Pr} \le 60 \\ 5 \times 10^5 \le \mathrm{Re}_L \le 10^7 \end{matrix}$$

Question (3) **[15 Marks]**

(a) A steam pipe with inner and outer diameters as 10 cm and 170 *mm* is covered with a 3 *cm* layer of insulation. Thermal conductivity of the insulating material is 0.175 W/m.K, while that of steel is 50 W/m K. The steam temperature is 150 °C and the air temperature is 20°C, h (steam side) = 100 W/m^2.K, h (air side) = 30 W/m^2.K. Determine the heat loss per m per hr from the pipe and the layer contact temperatures. If additional 50 mm thick insulating material with thermal conductivity of 0.093 W/m.K is added determine the percentage reduction in heat transfer due to the addition of the second layer of insulation.

a) Consider a medium in which the heat conduction equation is given in its simplest form as

$$\frac{1}{r}\frac{d}{dr}\left(rk\frac{dt}{dr}\right)+\frac{d}{dz}\left(k\frac{dt}{dz}\right)+q_v = 0$$

(a) Is heat transfer steady or transient?
(b) Is heat transfer one, two, or three dimensional?
(c) Is there heat generation in the medium?
(d) Is the thermal conductivity of the medium constant or variable?

Good Luck
Dr. Moustafa El Bouz