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: 21st January 2019** **Time: 2 Hours** **Full Mark: 50**

Question (1) : [20 Marks]

a) Define the following:

Thermal diffusivity, Fin effectiveness, Stanton number, Grashof number, Transmissivty and Opaque body.

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

a. Analogy between Heat and Mass transfer.

b. Flow across tube banks.

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

d. Thermal radiation & the electromagnetic wave spectrum.

e. Black body radiation & radiation shields.

c) A steam pipe of 10 cm inner diameter and 11cm outer diameter is covered with an insulating substance (kair = 1 W/m.K). The steam temperature is 200°C and ambient temperature is 20°C. If the convective heat transfer coefficient between insulating surface and air is 8 $W/m^2.K$, find the critical radius of insulation. For this value of r_c, calculate the heat loss per meter of the pipe and the outer surface temperature. Neglect the resistance of the pipe material.

Question (2) [18 Marks]

a) A horizontal electronic component of a medical device has a surface temperature of 35°**C**, 5 mm wide and 10 mm long dissipating 0.1 W by free convection from one side in to air where the temperature is 20°**C** *and* $k_{air} = 0.026\ W/m.K$. Determine the Nusselt number for air.

b) Determine the drag force per 1-m width of the plate acting over the distance 0.3 m from the leading edge. When air at atmospheric pressure and at 77°C flows over a flat plate with a velocity of 15 m/s. [For atmospheric air at 77°C $\upsilon = 20.76 \times 10^{-6}\ m^2/s$]

c) Consider the flow of water with a flow rate of *714 g/min* through a square duct 2cm by 2cm whose walls are maintained at a uniform temperature t_w=100°C. The flow is hydrodynamically and thermally developed. Calculate the heat transfer coefficient and determine the duct length required to heat the water from t_1= 30°C to t_2 = 70°C.

The properties of water are: [$\upsilon = 0.568 \times 10^{-6}$ m²/s, Pr = 4.32 and k = 0.64 W/(m.°C), cp = 4186 J/(kg.°C)].

$$Nu = 0.023\,\mathrm{Re}^{0.8}\,\mathrm{Pr}^{0.33} \begin{pmatrix} 0.7 \le \mathrm{Pr} \le 160 \\ \mathrm{Re} \succ 10{,}000 \end{pmatrix}$$ for turbulent flow

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Question (3) [12 Marks]

a) A counter flow, concentric tube heat exchanger is used to cool the lubricating oil for a large industrial gas turbine engine. The flow rate of cooling water through the inner tube (Di =25 mm) is 0.2 kg/s, while the flow rate of oil through the outer annulus (Do =45 mm) is 0.1 kg/s. The oil and water enter at temperatures of 100 and 30°C, respectively. If the overall heat transfer coefficient of the heat exchanger is 38.1 W/m².K. How long must the tube be made if the outlet temperature of the oil is to be 60°C?

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

$$\frac{dt}{d\tau} = \alpha\left(\frac{d^2t}{dx^2} + \frac{d^2t}{dy^2}\right) + q_v$$

(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
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