FACULTY: ENGINEERING

FIRST SEMESTER EXAMINATIONS

2016/ 2017 ACADEMIC SESSION

HOD'S SIGNATURE

COURSE CODE: MEE 409

COURSE TITLE: HEAT TRANSFER II – 3 UNITS

DURATION: 2 HOURS

INSTRUCTIONS

1. ATTEMPT ANY **THREE** QUESTIONS OF YOUR CHOICE
2. SEVERE PENALTIES APPLY FOR MISCONDUCT, CHEATING, POSSESSION OF UNAUTHORIZED MATERIALS DURING EXAM
3. YOU ARE NOT ALLOWED TO BORROW CALCULATORS AND ANY OTHER WRITING MATERIALS

ELIZADE UNIVERSITY

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DEPARTMENT OF MECHANICAL ENGINEERING

COURSE — HEAT TRANSFER

DATE: March 2017

TIME ALLOWED - 2 HOURS

INSTRUCTION - ANSWER ANY 3 QUESTIONS

1.(i) What is heat transfer?

(ii) what are the applications of the knowledge of heat transfer?

(iii) Explain the mechanism of heat transfer in solid conductor of electricity, a solid non conductor of electricity, in a fluid and through a vacuum.

(iv) Sketch an experimental set up to show that heat conductor is governed by Fourier equation $Q \propto \frac{A\Delta T}{\Delta x}$

(v) show that for heat conduction in an element of materials in cylindrical coordinate, the energy balance within the element, the energy balance is given by

$$\frac{\partial T}{\partial t} = \propto \left[\frac{\partial^2 T}{\partial r2} + \frac{1}{r}\frac{\partial T}{\partial r} + \frac{1}{r^2}\frac{\partial^2 T}{\partial \theta^2} + \frac{\partial^2 T}{\partial z^2}\right] + \frac{q}{\rho cp}$$

Where T = temperature, t = time q = the rate of heat generation per unit volume, $\propto = \frac{k}{\rho cp}$ (thermal diffusivity), ρ = density, c_p = specific heat.

2. The interior of a refrigerator, having inside dimensions 0.46m by 0.46m base area and 1.24m height, is to be maintained at 7.2°C. the walls of the refrigerator are constructed of two 3.2mm mild-steel sheets with 7.6cm of glass-wool insulation between them. If the average heat transfer coefficients at the inner and outer surfaces are 11.4 and 14.2W/m^2°C, respectively, estimate the rate at which heat must be removed from the interior to maintain the specified temperature in a kitchen at 29.4°C. What will be the temperature at the outer surface of the wall? Data: Thermal conductivity of mild-steel = 43.3 Wm/m2°C.

Thermal conductivity of glass wool = 0.039 Wm/m^2°C.

3) Show that the temperature profile of a fin of uniform cross section is given by

$$0 - C_1 e^{mx} + C_2 e^{-mx}$$

$$m = -\sqrt{\frac{hp}{kA}}$$

$\theta = T - T_\infty$ $T_\infty = surrounding\ temperature$

If the fin is in infinite in length show that $\frac{\theta}{\theta_o} = e^{-mx}$

4) What are the assumptions on which Reynolds analogy is based? Show from first principles that Reynolds analogy for a turbulent flow leads to the equation.

$$S_1 = \frac{C_f}{2}$$

Where $St = \frac{h}{\rho U_G C_p}$. $Cf = \frac{\tau_W}{\frac{1}{2}\rho U^2{}_G}$. $h = \frac{q}{T_W - T_G}$

Water flows with a velocity of 2.44 m/s through a tube of 2.54 cm inside diameter and 6.08 m long. The head lost due to friction was 1.22 m of water. Assuming Reynolds number, estimate the heat transfer coefficient.

5) Show that for a courier flow heat exchanger the logarithmic mean temperature difference

is given by $\theta_m = \dfrac{\theta_o - \theta_i}{\text{In}\,\frac{\theta_o}{\theta_i}}$

Where θ_i is the temp difference at one end of the heat exchanger and θ_o is the temperature difference at the other end.

A tubular counter flow oil cooler is to use a supply of cold water as the cooling fluid. The oil enters the tube at 121°C and exists at 82.3°C.

The cooling water enters at 15.6°C. The oil flow rate is 0.189kg/sec while the water flows at 0.373 kg/sec. The specific heat of oil is 2094J kg°C. and that of water is 4187 J/kg °C. Calculate the logarithmic mean temperature difference.

6) Define the terms emissivity, absorptivity, transmissivity, reflectivity and grey body. Show that the radiation heat transfers between two parallel surfaces is given by

$$q = \frac{\varepsilon_1 \varepsilon_2}{\varepsilon_1 + \varepsilon_2 - \varepsilon_1 \varepsilon_2} \sigma(T_1^4 - T_2^4)$$

Two large surfaces at small distance apart are maintained at 1000°C and 500°C Determine the net rate transfer between them in k W/m2. $\sigma = 5.663x10^{-8}$