Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2014/2015

COURSE NAME	:	HEAT TRANSFER
COURSE CODE	:	BDA 30603
PROGRAMME	:	3 BDD
EXAMINATION DATE	:	JUNE 2015/JULY 2015
DURATION	:	3 HOURS
INSTRUCTIONS	:	ANSWER **FIVE (5)** FROM **SEVEN (7)** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 Figure **Q1** shows a hot surface at 100 °C, which is to be cooled by attaching 3 cm-long, 0.25 cm-diameter aluminum pin fins (k=237 W/m·K) to it, with a center-to-center distance of 0.6 cm. The temperature of the surrounding medium is 30 °C, and the heat transfer coefficient on the surfaces is 35 W/m^2.K.

(a) Determine the rate of heat transfer from the surface for a 1-m x 1-m section of the plate.

(16 marks)

(b) Determine the overall effectiveness of the fins.

(4 marks)

Q2 (a) A 3 mm-diameter and 5 m-long electric wire is tightly wrapped with a 2 mm-thick plastic cover whose thermal conductivity is k=0.15 W/m.K. Electrical measurements indicate that a current of 10 A passes through the wire and there is voltage drop of 8 V along the wire. If the insulated wire is exposed to a medium at ambient temperature T=30 °C with a heat transfer coefficient of h=12 W/m^2.K:

(i) determine the temperature at the interface of the wire and the plastic cover in steady operation; and

(5 marks)

(ii) determine whether doubling the thickness of the plastic cover will increase or decrease this interface temperature.

(5 marks)

(b) A person is found dead at 5 pm in a room whose temperature is 20 °C. The temperature of the body is measured to be 25°C when found, and the heat transfer coefficient is estimated to be h=10W/m^2 °C. Modelling the body as a 35 cm-diameter, 1.8 m-long cylinder, estimate the approximate time of death of that person. Assuming the body to have the properties of water at 31 °C:

(i) calculate the Biot number and show whether or not the lumped system analysis is appropriate for this problem?

(5 marks)

(ii) Assuming that a lumped system analysis is valid, calculate the approximate time of death.

(5 marks)

Q3 The cylinder head of a small motorcycle is cooled by five flat plates on its surface as shown in Figure **Q3 (a)**. Three of the plates located in the middle are 80 mm in length and 15 mm in height. The other two plates which are located at the sides are 60 mm in length and 15 mm in height. The surface temperature of the plates are assumed to be equal to that of the cylinder head at 70 °C whereas the outside air temperature is 30 °C. If the outside air travelling parallel to the plates at 25 m/s, determine:

(a) the hydraulic boundary layer thickness at the trailing edge of the 80 mm long plate and 60 mm long plate;

(4 marks)

(b) the total friction drag along the surface of the plates;

(4 marks)

(c) the heat transfer rate from a single 60 mm long plate and a single 80 mm long plate;

(4 marks)

(d) the total heat transfer from all plates; and

(2 marks)

(e) Given the same flow conditions, determine whether there is an advantage in terms of heat transfer if five identical elliptical plates with dimensions shown in Figure **Q3 (b)** are used instead of the flat plates.

(6 marks)

Q4 Figure **Q4** shows a door panel of a car with surface temperature of 25 °C. The panel, which is 0.3 m in height and 0.6 m in width is "oven-baked" and left to dry in a paint booth where the ambient air is at 55 °C. A fan is installed to blow air parallel to the surface of the panel at a speed of 5 m/s. Calculate:

(a) the heat transfer rate between the panel surface and the surroundings without the fan;

(9 marks)

(b) the total rate of heat transfer between the panel surface and the surroundings when the fan is turned on; and

(9 marks)

(c) the percentage of heat transfer due to natural convection and determine whether natural convection is significant in this case.

(2 marks)

Q5 (a) During an experiment, a plate heat exchanger that is used to transfer heat from a hot water stream to a cold water stream is tested, and the following measurements are taken:

	Hot water stream	Cold water stream
Inlet Temperature (°C)	36.0	10.3
Outlet Temperature (°C)	24.0	15.8
Volume Flow Rate (L/min)	2.5	4.5

If the heat transfer area is calculated to be 0.056 m^2, determine:

(i) the rate of heat transfer to the cold water;
(ii) the overall heat transfer coefficient;
(iii) the heat transfer efficiency; and
(iv) the effectiveness and the NTU values of the heat exchanger.

(10 marks)

(b) Referring to the heat exchanger in **Q5 (a)**, discuss if the heat exchanger is truly adiabatic.

(3 marks)

(c) A shell and tube heat exchanger with 2-shell passes and 4-tube passes is used for cooling oil (C_p = 2.0 kJ/kg·K) from 125 °C to 55 °C. The coolant is water, which enters the shell side at 25 °C and leaves at 46 °C. The overall heat transfer coefficient is 900 W/m^2·K. For an oil flow rate of 10 kg/s, calculate the water flow rate and the heat transfer area associated to the heat exchanger.

(7 marks)

Q6 (a) Determine the radiation view factors F_{12} and F_{21} for the geometries illustrated in Figure **Q6 (a)**, **(b)**, and **(c)**.

(10 marks)

(b) Two black parallel, coaxial discs, each of diameter 0.5 m, are separated by a distance of 0.5 m. The temperatures of the discs are T_1 and T_2 are 20 °C and 60 °C respectively while the surroundings are at T_3 = 28°C. The rear surfaces of the discs are well insulated. Taking the emissivity of the surfaces as 0.9, calculate the rate of radiative heat transfer from the hot disc to:

(i) the cooler disc; and

(ii) the surroundings.

(10 marks)

Q7 (a) As an engineer of a company, you have been assigned to evaluate a proposal to improve the effectiveness of a heat exchanger. At present, the heat exchanger has a NTU of 4. The proposal is to double the size of the heat exchanger, thus double the NTU to 8 to increase the effectiveness. Discuss your evaluation on the proposal.

(4 marks)

(b) Hot water ($C_{p,h}$ = 4188 J/kg.K) with mass flow rate of 2.5 kg/s at 100 °C enters a thin-walled concentric tube counter-flow heat exchanger with a surface area of 23 m^2 and an overall heat transfer coefficient of 1000 $W/m^2.K$. Cold water ($C_{p,w}$ = 4178 J/kg.K) with mass flow rate of 5 kg/s enters the heat exchanger at 20 °C, determine:

i) the heat transfer rate for the heat exchanger; and

ii) the outlet temperature of the cold and hot fluids.

(13 marks)

(c) After a period of operation, the overall heat transfer coefficient of heat exchanger in **Q7 (b)** is reduced to 500 $W/m^2.K$, determine the fouling factor that caused the reduction in the overall heat transfer coefficient.

(3 marks)

- END OF QUESTIONS –

FINAL EXAMINATION

SEMESTER/SESSION: SEM II/2014/2015 PROGRAMME: 3 BDD
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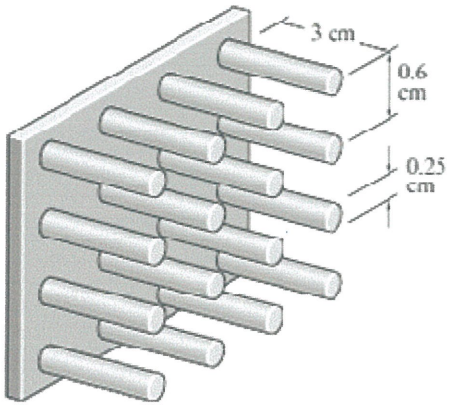

FIGURE Q1

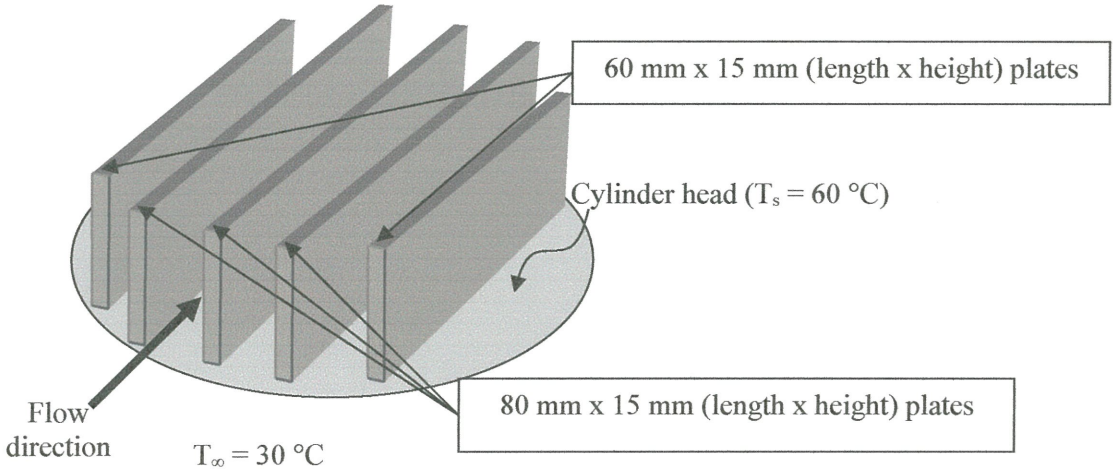

FIGURE Q3 (a)

FINAL EXAMINATION

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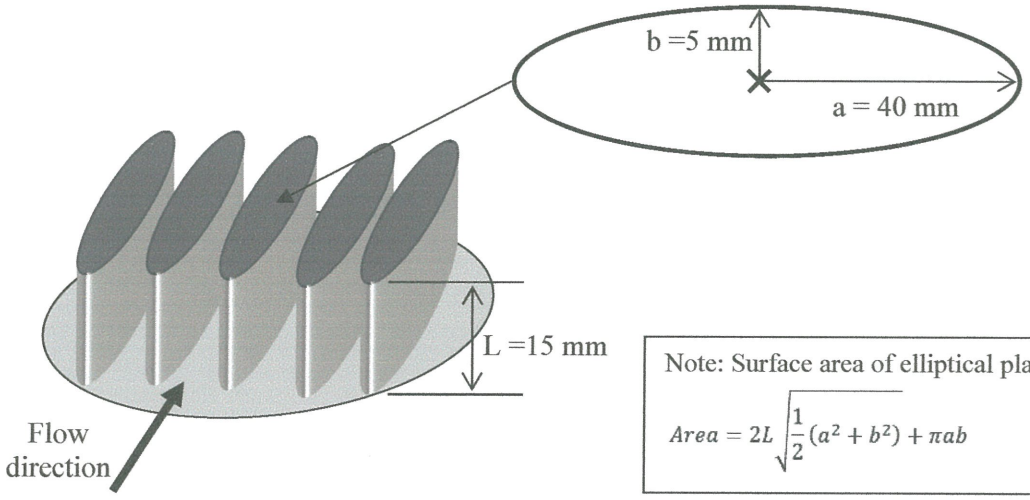

Note: Surface area of elliptical plates:

$$Area = 2L\sqrt{\frac{1}{2}(a^2 + b^2) + \pi ab}$$

FIGURE Q3 (b)

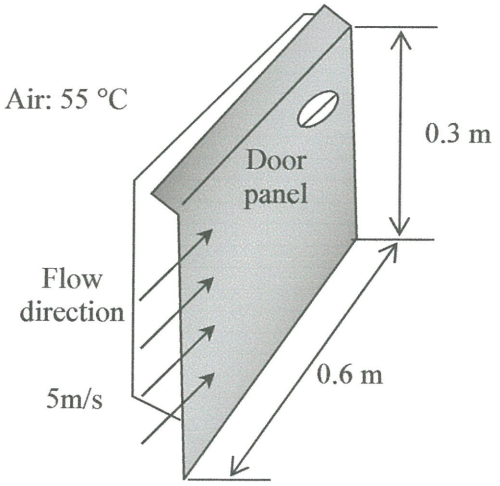

FIGURE Q4

FINAL EXAMINATION

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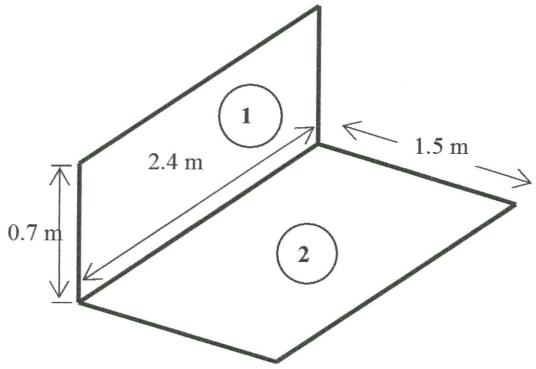

FIGURE Q6 (a)

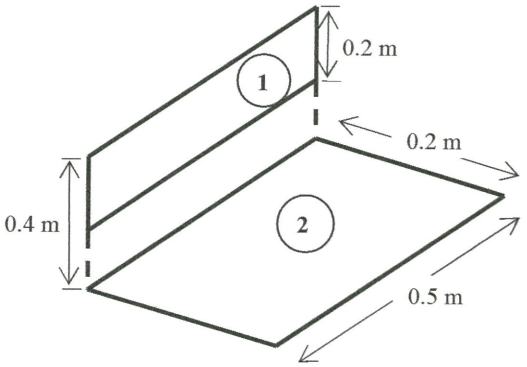

FIGURE Q6 (b)

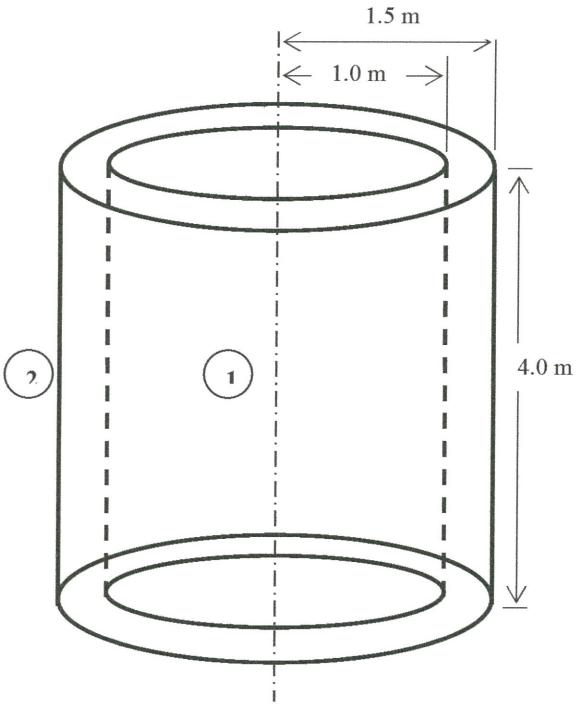

FIGURE Q6 (c)