Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	HEAT TRANSFER
COURSE CODE	:	BNL 30703
PROGRAMME CODE	:	BNL
EXAMINATION DATE	:	JUNE / JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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

Q1 Consider a 5 m high, 8 m long, and 0.22 m thick wall whose representative cross section is as given in the **Figure Q1**. The thermal conductivities of various materials used, in W/m.K, are $k_A = k_F = 2$, $k_B = 8$, $k_C = 20$, $k_D = 15$, and $k_E = 35$. The left and right surfaces of the wall are maintained at uniform temperatures of 300 °C and 100 °C, respectively. It is assumed that heat transfer through the wall to be one-dimensional.

(a) Show the thermal resistance network.

(1 marks)

(b) Determine the individual and total thermal resistances.

(10 marks)

(c) Calculate the rate of heat transfer through the wall.

(4 marks)

(d) Determine the temperature at the point where the sections B, D, and E meet.

(3 marks)

(e) Calculate the temperature drop across the section F. Disregard any contact resistances at the interface.

(2 marks)

Q2 A 15 cm × 20 cm integrated circuit board is to be cooled by attaching 4 cm long aluminum (k = 237 W/m.K) fins on one side of it, as shown in **Figure Q2**. Each fins has a 2 mm × 2 mm square cross section. The surrounding ambient temperature is 25 °C and the convection heat transfer coefficient on each fin surface is 20 W/m^2.K. To prevent the circuit board from overheating, the upper surface of the circuit board needs to be at 80 °C or cooler.

(a) Determine the fin efficiency(η_{fin}).

(4 marks)

(b) Identify the finned and unfinned surface areas.

(4 marks)

(c) Determine the heat transfer rate for both finned and unfinned surfaces.

(4 marks)

(d) Calculate the total heat transfer rate from the circuit board.

(4 marks)

(e) Determine the rate of heat transfer if there were no fins attached to the plate.

(4 marks)

(f) Determine the appropriate number of fins with an overall effectiveness of 3 that can keep the circuit board surface from overheating.

(3 marks)

Q3 Consider a 0.6 m × 0.6 m this square plate in a room at 30 °C. One side of the plate is maintained at a temperature of 90 °C, while the other side is insulated, as shown in **Figure Q3**. The properties of air at the film temperature of 60 °C and 1 atm are given below.

$k = 0.02808$ W/m.K $\qquad$ $\Pr = 0.7202$

$\nu = 1.896 \times 10^{-5}$ m²/s $\qquad$ $\beta = \dfrac{1}{T_f}$

By referring to the **Table Q3**, determine the rate of heat transfer from the plate by natural convection if the plate is;

(a) Vertical.

(10 marks)

(b) Horizontal with hot surface facing up.

(10 marks)

Q4 (a) (i) Draw a 1-shell-pass and 6-tube-passes shell-and-tube heat exchanger.

(2 marks)

(ii) Provide **ONE (1)** advantage and **ONE (1)** disadvantage of using 6 tube passes instead of just 2 of the same diameter.

(2 marks)

(b) Engine oil (C_p = 2100 J/kg.°C) is to be heated from 20°C to 60°C at a rate of 0.3 kg/s in a 2 cm diameter thin walled copper tube by condensing steam outside at a temperature of 130 °C (h_{fg} = 2174 kJ/kg), as shown in **Figure Q4(b)**. For an overall heat transfer coefficient of 650 W/m^2.°C,

(i) Determine the rate of heat transfer.

(3 marks)

(i) Calculate the length of the tube required to achieve it.

(8 marks)

(c) Consider two double-pipe counter-flow heat exchangers that are identical except that one is twice as long as the other one. Evaluate which type of heat exchanger is more likely to have a higher effectiveness

(3 marks)

Q5 (a) (i) Define a blackbody.

(2 marks)

(ii) Discuss whether a blackbody is actually exist or not. Explain your reasons.

(4 marks)

(b) Describe the driving force for;

(i) Heat transfer
(ii) Electric current flow
(iii) Fluid flow

(3 marks)

(c) Consider two identical rooms, one with a refrigerator in it and the other without one. If all the doors and windows are closed, describe which rooms will be warmer. Explain your reason.

(5 marks)

(d) The deep human body temperature of a healthy person remains constant at 37 °C while the temperature and the humidity of the environment change with time. Discuss the heat transfer mechanisms between the human body and the environment both in summer and winter, and explain how a person can keep cooler in summer and warmer in winter.

(6 marks)

-END OF QUESTIONS –

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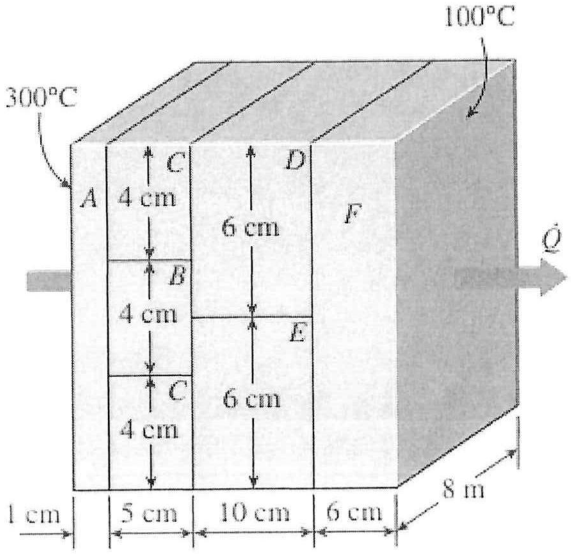
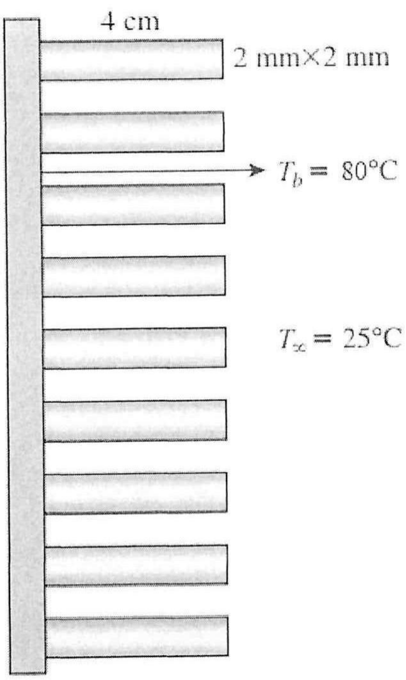


Figure Q1



Straight rectangular fins

$$m = \sqrt{\frac{hp}{kA_c}} = \sqrt{\frac{4ha}{ka^2}}$$

$$\eta_{fin} = \frac{\tanh mL}{mL}$$

$$A_{fin} = 2wL_c$$

$$L_c = L + t/2$$

$$\dot{Q}_{finned} = \eta_{fin}\dot{Q}_{fin,max} = \eta_{fin}hA_{fin}(T_b - T_\infty)$$

$$\dot{Q}_{unfinned} = hA_{unfinned}(T_b - T_\infty)$$

$$\dot{Q}_{no\,fin} = hA_{no\,fin}(T_b - T_\infty)$$

$$\varepsilon_{fin} = \frac{\dot{Q}_{fin}}{\dot{Q}_{no\,fin}}$$

Figure Q2

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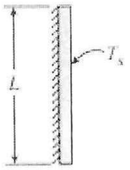
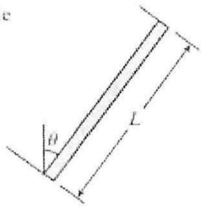
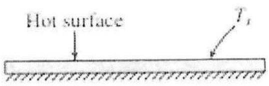
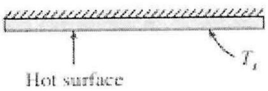
Table Q3

Geometry	Characteristic length L_c	Range of Ra	Nu
Vertical plate 	L	10^4–10^9 10^{10}–10^{13} Entire range	$Nu = 0.59Ra_L^{1/4}$ (9–19) $Nu = 0.1Ra_L^{1/3}$ (9–20) $Nu = \left\{0.825 + \frac{0.387Ra_L^{1/6}}{[1 + (0.492/Pr)^{9/16}]^{8/27}}\right\}^2$ (9–21) (complex but more accurate)
Inclined plate 	L		Use vertical plate equations for the upper surface of a cold plate and the lower surface of a hot plate Replace g by $g\cos\theta$ for $0 < \theta < 60°$
Horizontal plate (Surface area A and perimeter p) (a) Upper surface of a hot plate (or lower surface of a cold plate)  (b) Lower surface of a hot plate (or upper surface of a cold plate) 	A_s/p	10^4–10^7 10^7–10^{11} 10^5–10^{11}	$Nu = 0.59Ra_L^{1/4}$ (9–22) $Nu = 0.1Ra_L^{1/3}$ (9–23) $Nu = 0.27Ra_L^{1/4}$ (9–24)

(i) $Ra_L = \frac{g\beta(T_S - T_\infty)L^3}{v^2} Pr$

(ii) $Nu = \frac{hL}{k}$ or $Nu = \frac{hL_c}{k}$

(iii) $Ra_L = \frac{g\beta(T_S - T_\infty)L_c^3}{v^2} \text{Pr}$; $L_c = \frac{A_S}{p} = \frac{L^2}{4L}$

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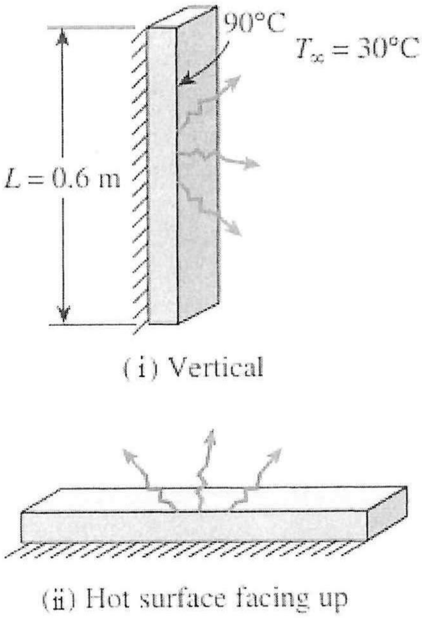
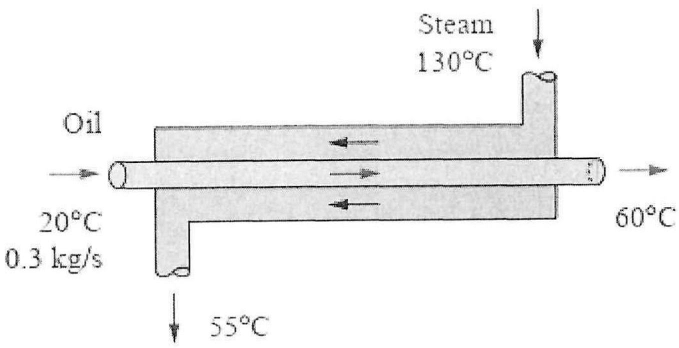


Figure Q3



$$\dot{Q} = [\dot{m}c_p(T_{out} - T_{in})]$$

$$\Delta T_{lm} = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1/\Delta T_2)}$$

$$A_s = \frac{\dot{Q}}{U\,\Delta T_{lm}}$$

Figure Q4 (b)