Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER 1
## SESSION 2018/2019

| | | |
|---|---|---|
| COURSE NAME | : | HEAT TRANSFER |
| COURSE CODE | : | BDA 30603 |
| PROGRAMME | : | BDD |
| EXAMINATION DATE | : | DECEMBER 2018/ JANUARY 2019 |
| DURATION | : | 3 HOURS |
| INSTRUCTION | : | ANSWER **FIVE (5)** QUESTIONS **ONLY** |

THIS QUESTION PAPER CONSISTS OF **SEVEN ( 7 )** PAGES

**Q1** (a) List 3 types of fin by the aid of illustration.

(5 marks).

(b) **Figure Q1 (b)** shows a rectangular plate with 10 fins of similar sizes arranged on its surface for cooling purpose. The dimensions of the arrangement are shown in the figure. Surface temperature of the plate is 125° C and the air temperature is 30° C. The heat transfer coefficient is 150 W/m$^2$K. If the plate and fin material is aluminum, calculate:

(i) heat transfer from the plate surface if no fins are installed;

(2 marks)

(ii) heat transfer from one fin and tip temperature;

(6 marks)

(iii)total heat transfer from all fins;

(2 marks)

(iv)total heat transfer from the arrangement; and

(3 marks)

(v) percentage of heat dissipation enhancement by adding fins to the plate.

(2 marks)

**Q2** (a) Explain combination criteria for a fin Biot number and what's the different between Biot number and Nusselt Number.

(5 marks)

(b) Chickens with an average mass of 1.7 kg ($k$ = 0.45W/m · °C and $\alpha$= 0.13 x 10-$^6$ m$^2$/s) initially at a uniform temperature of 15°C are to be chilled in agitated brine (water with salt) at 10°C. The average heat transfer coefficient between the chicken and the brine is determined experimentally to be 440 W/m$^2$ · °C. Taking the average density of the chicken to be 0.95 g/cm3 and treating the chicken as a spherical lump, determine the center and the surface temperatures of the chicken in 2h and 30 min. Also, determine if any part of the chicken will freeze during this process. {Use $r_o = \left(\frac{3}{4\pi}V\right)^{1/3}$ }

(15 marks)

**Q3** (a) Consider fully developed flow in a pipe. Will the friction factor *increase*, *decrease* or *constant* if the flow is:

(i) laminar;
(ii) transition; and
(iii) turbulent;

(3 marks)

(b) If the pipe length in (a) above is double, what will happen to the pressure drop?

(3 marks)

(c) In a wood factory, hot air is used to dry the finished products in a drying bay. The hot air was supplied to the drying bay using a square duct of 25 cm x 25 cm with a total length of 10 m. The hot air flow rate is 0.25 $m^3/s$. The duct surface can be assumed to be isothermal at 80 °C. Assuming the entire flow is fully developed and the internal duct surface is smooth, determine:

(i) heat transfer from the duct to the drying bay; and
(ii) the pressure difference between inlet and outlet of the duct

(14 marks)

**Q4** (a) Hot-thin metal plates of 8' x 4' are manufactured at a factory. The current practice of the factory is to allow the plates to cool by itself through natural convection. Due to the recent increase of production, the factory management decided to reduce the cooling time of the hot plates using an industrial fan. Propose the best configuration for faster cooling by sketching the plate orientation and fan location.

(5 marks)

(b) A 0.12 m high and 0.2 m wide computer motherboard houses 100 closely spaced electronic components on its surface, each dissipiating 0.05 W. The motherboard is colled by a small fan from the bottom (along the 0.12 m long side) at 35°C at a velocity of 0.5 m/s. The motherboard's temperature can be taken as 60 °C. Neglecting the heat transfer from the back of the motherboard, calculate the combined heat transfer by natural convection and forced convection.

(15 marks)

**Q5** (a) List three (3) common causes of fouling in a heat exchanger.

(3 marks)

(b) Explain how fouling affects heat transfer and pressure drop.

(2 marks)

(c) A 1-shell pass and 8-tube passes heat exchanger is used to heat glycerin ($C_p$ = 2.5 kJ/kg. °C) from 18 °C to 60 °C by hot water ($C_p$ = 4.18 kJ/kg. °C) that enters the thin-walled 1.3 cm diameter tubes at 80 °C and leaves at 50 °C. The total length of the tubes in the heat exchanger is 150 m. The convection heat transfer coefficient is 23 W/m$^2$. °C on the glycerin (shell) side and 280 W/m$^2$. °C on the water (tube) side. Determine the rate of heat transfer in the heat exchanger;

(i) before any fouling occurs; and

(ii) after fouling with a fouling factor of 0.0007 m$^2$. °C/W on the outer surfaces of the tubes

(15 marks)

**Q6** (a) Consider a heat exchanger in which both fluids have the same specific heats but different mass flow rates. Which fluid will experience a larger temperature difference; the one with the lower or higher mass flow rate?

(3 marks)

(b) Consider a heat exchanger that has an NTU of 0.5. Someone proposes to triple the size of the heat exchanger and thus triple the NTU to 1.5 in order to increase the effectiveness of the heat exchanger and thus save energy. Would you support this proposal?

(2 marks)

(c) A cross-flow heat exchanger as shown in **Figure Q6 (c)** consists of 200 thin-walled tubes of 10 cm diameter located in a duct of 2 m x 2 m cross section. There are no fins attached to the tubes. Cold water ($C_p$ = 4180 J/kg. K) enters the tubes at 18 °C with a mass flowrate of 3 kg/s, while hot air ($C_p$ = 1254 J/kg.K) enters the channel at 130 °C with a mass flowrate of 5 kg/s. If the overall heat transfer coefficient is 130 W/m$^2$. K, determine;

(i) the oulet temperatures of both fluids; and

(ii) the rate of heat transfer..

(15 marks)

**Q7** (a) Consider an absorber surface of a solar collector is made of aluminum coated with black chrome ($\alpha_s = 0.87$ and $\varepsilon = 0.09$) as in **Figure Q7 (a)**. Solar radiation is incident on the surface at a rate of 720 W/m$^2$. The air and the effective sky temperatures are 25 °C and 15 °C respectively, and the convection heat transfer coefficient is 10 W/m$^2$K. If the absorber surface temperature recorded to be at 70 °C, determine the net rate of solar energy delivered by the absorber plate to the water circulating behind it.

(10 marks)

(b) Liquid Nitrogen is stored in a spherical tank of 1 m diameter, where the tank surface is maintained uniformly at 80K. The spherical tank is enclosed by a 1.6 m diameter concentric sphere with uniform surface temperature of 273 K. Both spherical surface have an emissivity of 0.01, and the gap between the inner and outer sphere is vacuumed. If the latent heat of evaporation of nitrogen is at 196.8 kJ/kg, determine the rate of evaporation for the liquid nitrogen.

(10 marks)

**- END OF QUESTION -**

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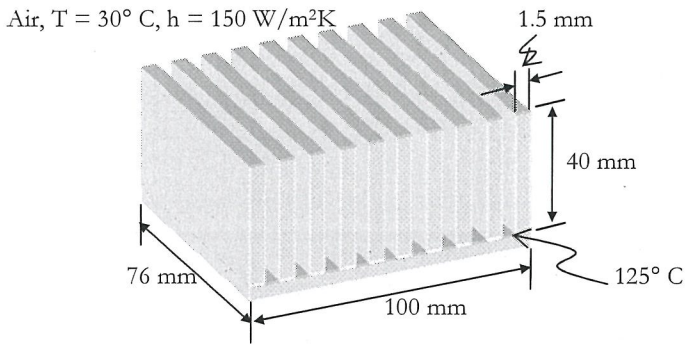


**Figure Q1 (b)**

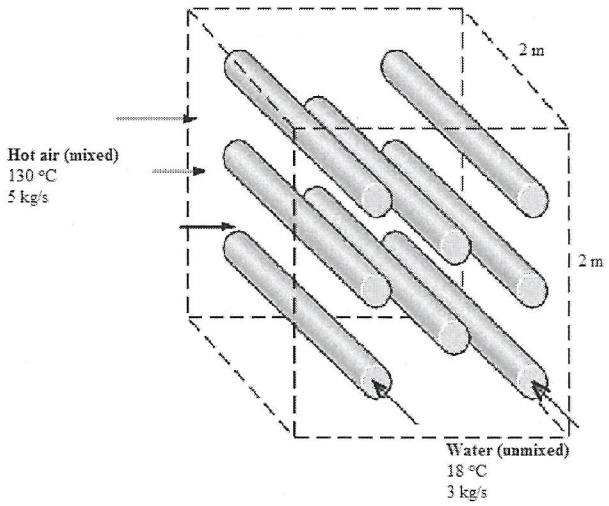


**Figure Q6 (c)**

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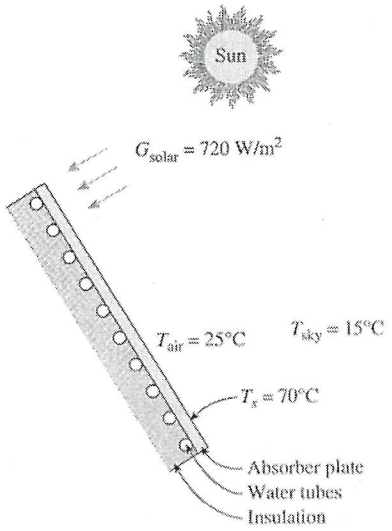


**Figure Q7 (a)**