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CONFIDENTIAL

SET B

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
JANUARY 2010 SESSION

SUBJECT CODE	:	FRD 20303
SUBJECT TITLE	:	HEAT TRANSFER & HEAT EXCHANGER
LEVEL	:	DIPLOMA
TIME / DURATION	:	9.00am – 12.00pm (3 HOURS)
DATE	:	05 MAY 2010

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. Please write your answer on the answer booklet provided.
4. Answer should be written in blue or black ink except for sketching, graphic and illustration.
5. This questions paper consists of TWO (2) sections. Section A and B. Answer ALL questions in section A. For section B answer TWO (2) questions only.
6. Answer all questions in English.

THERE ARE 6 PAGES OF QUESTIONS AND 3 PAGES OF APPENDIX, EXCLUDING THIS PAGE.

SECTION A (Total: 60 marks)

INSTRUCTION: Answer ALL questions.
Please use the answer booklet provided.

Question 1

a) 3 methods of heat transfer are conduction, convection and radiation.

i. What is the unit for heat transfer rate in **SI** and **IP** ?

(2 marks)

ii. Between Copper and glass, which one has the higher thermal conductivity? Why?

(6 marks)

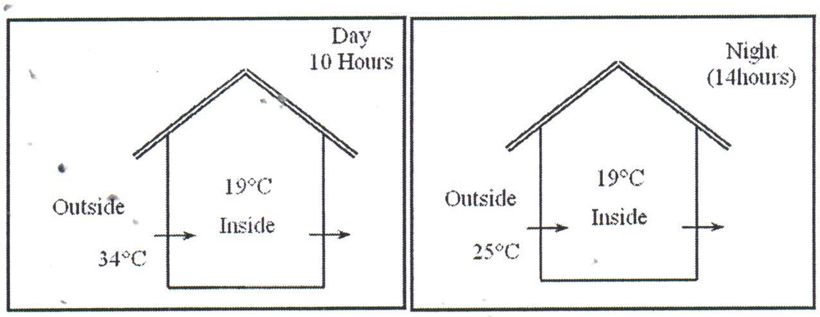

Figure Q1: Heat transfer by conduction in 24 hours

Figure Q1 shows a house which walls have area of 5.4 m x 3.2 m x 2 walls and wall thickness is 30 cm. The temperatures inside is 19 ^{0}C . The thermal conductivity of the brick wall is given to be k = 0.70 W/m·°C. Calculate:-

b) The rate of heat transferred into the house during **day** and **night** in W

(6 marks)

c) The amount of heat transferred (kWh) into the house in **10 hours** for day and **14 hours** for night

(6 marks)

QUESTION 2

a) The difference between conduction and convection is that the heat transfer through the fluid is much higher by convection. What is the similarity between conduction and convection?

(2 marks)

b) Describe 2 types of convection.

(3 marks)

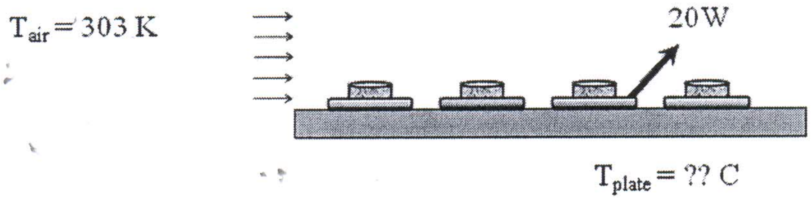

Figure Q2: Heat transfer by Convection

Four power transistors each with a hot plate surface area 20 cm x 40 cm are mounted on a thin vertical aluminum plate that is cooled by a fan. The convective heat transfer coefficient is 25 W/m^2.C uniform over the surface and the rate of heat transfer of each transistor is 20 W. Calculate:-

c) The temperature of the aluminum plate in ^{0}C

(7 marks)

d) The new rate of heat transfer by convection (in W) if the air temperature air is 17 ^{0}C

(4 marks)

e) What will happen to the rate of heat transfer if the air temperature (Figure Q2) decreases to 17 ^{0}C? Why?

(4 marks)

QUESTION 3

a) Define the meaning of:-

i. heat transfer by radiation

(4 marks)

ii. Black body

(2 marks)

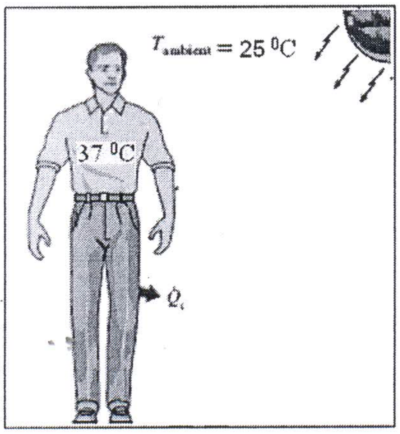

Figure Q3: Radiant emitted to person

Referring to figure Q3, in summer, a person (average surface area = 1.6 m^2) has a body temperature of 37 ^{0}C and the ambient temperature of 25 ^{0}C. Give the Stefan Boltzman coefficient as 5.676 x 10^{-8} $W/m^2.K^4$ and the person is a **black body**, Calculate:-

b) The rate of radiant heat transfer emitted by the person, in W

(5 marks)

c) The rate of heat transfer by radiation if the person is a "grey bodies", and the emissivity is 0.80

(5 marks)

d) What conclusion can be discussed from answer 3(b) and 3(c)?

(4 marks)

SECTION B (Total: 40 marks)

INSTRUCTION: Answer only TWO questions.
Please use the answer booklet provided.

QUESTION 4

a) Total Resistance consists of 3 parameters one of which is Thermal Conductance. What are the other 2 parameters of total resistance?

(4 marks)

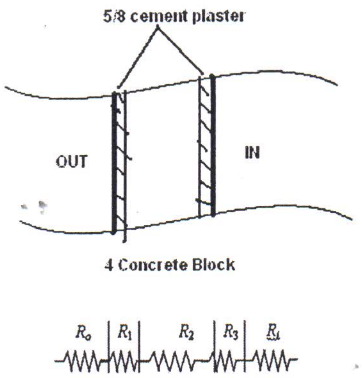

Figure Q4: Slab resistance with plastered layer

Referring to figure Q4, a 24 ft x 26 ft area of wall with 4in thick concrete block is plastered with two layers of 5/8in thick cement plaster. The thermal conductance for concrete block, $C_{Concrete}$ = 8 Btu/hr•°F• ft^2 and conductivity for cement plaster, $K_{cement\ plaster}$ = 5 Btu.in/hr•°F• ft^2 with the outside temperature 90^{0}F and inside temperature is 77 °F. The resistance outside, R_{out} = 0.61 ft^2.hr.F / BTU and resistance inside, R_{in} = 0.68 ft^2.hr.F / BTU. Calculate:-

b) The Total Thermal resistance through the wall,in hr.ft^2.F/BTU

(6 marks)

c) The U-value coefficient, in Btu/hr.ft^2.F

(4 marks)

d) The heat transmission loss through the slab, Btu/hr

(4 marks)

e) The total resistance, (hr.ft^2.F/Btu) if the cement plaster thickness increases to 1 inch

(4 marks)

QUESTION 5

a) Describe the temperature profile for the following flow structure by sketching the temperature profile figure to support your answer:-

  i. Parallel Flow heat exchanger operation and,

  ii. Counter Flow heat exchanger operation

(6 marks)

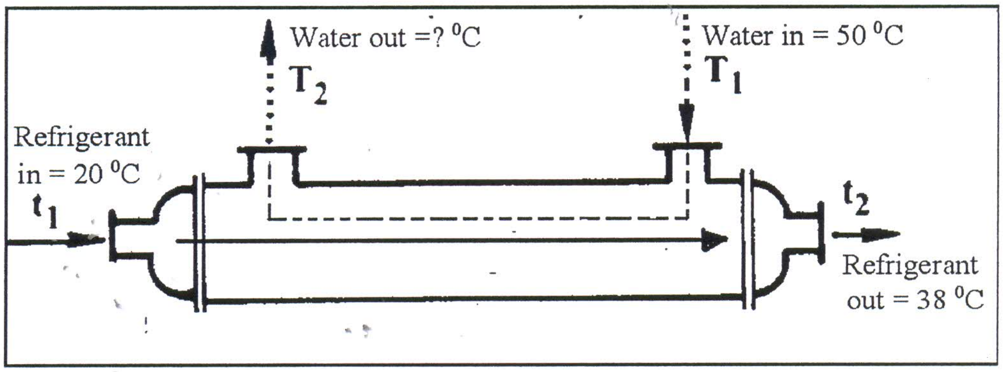

Figure Q5: Heat Exchanger

Referring figure Q5, water (mC_p=4500 W/k) enter the heat exchanger at 50 ^{0}C and exchanges energy with inside tube having refrigerant entering at 20^{0}C and leaving is 38^{0}C. Given the cooling capacity is 72 kW, calculate:

b) The exit temperature of the hot fluid, in ^{0}C

(5 marks)

c) Whether the exchanger operated in <u>parallel flow</u> or <u>counter flow</u>? (Please show the temperature profile in a figure)

(4 marks)

d) The Log Mean Temperature Difference, ΔLMTD in ^{0}C

(5 marks)

QUESTION 6

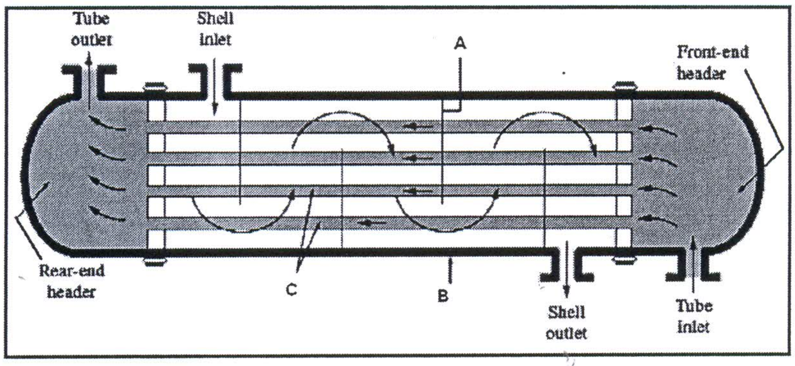

Figure Q6: Major component of a Shell-And-Tube heat exchanger

(a) Referring to figure Q6, name the components labeled as A, B & C. What is the function of component A?

(5 marks)

Consider the following parallel flow heat exchanger for air and water and the transmission surface is steel with the following specification:

Area, A = 25 m^2
U-value Overall heat transfer coefficient: 45 $W/m^2.K$
Hot fluid A temperature = 150 C with Mass flow rate = 5 kg/s
Cold fluid B temperature = 25 C with Mass flow rate = 1 kg/s
Specific heat for fluid A = 1040 J/kg.k
Specific heat for fluid B = 1040 J/kg.k
Calculate:-

(b) The Capacitance rate of C_{max} and C_{min}

(2 marks)

(c) Value of NTU method and Number of capacitance ratio, C_r

(6 marks)

(d) Sketch in Appendix 1 (To be returned), the value of heat exchanger effectiveness?

(3 marks)

(e) The rate of heat exchanger, in kW

(4 marks)

END OF QUESTION

APPENDIX 1 (MUST BE RETURNED)

The effectiveness of parallel and counter-flow heat exchangers from CHART

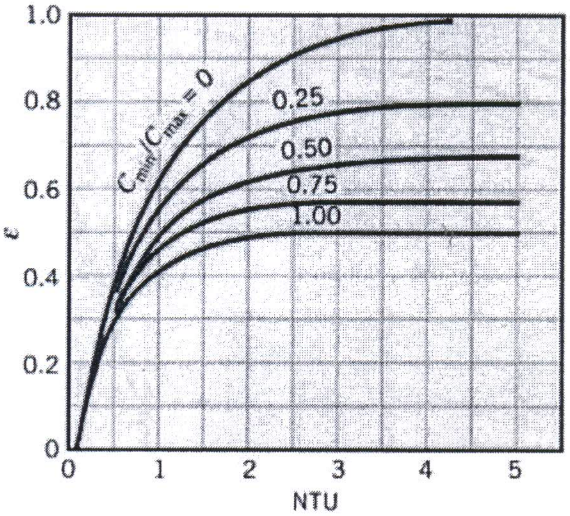

FIGURE 11.14 Effectiveness of a parallel-flow heat exchanger

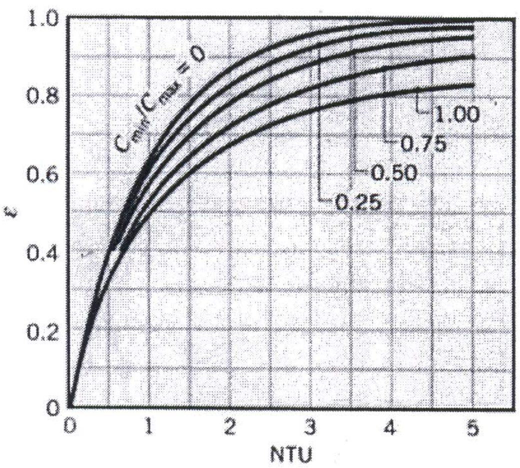

FIGURE 11.15 Effectiveness of a counterflow heat exchanger

APPENDIX 2

1. Heat Flux

$$\dot{q} \equiv \frac{\dot{Q}}{A}.$$

Where, q = heat Flux, (W/m. or BTU/hr.ft.)

Q = Heat flow rate (Watt or BTU/hr)

A = Area to the direction of heat flow (m^2 or ft^2)

2. Fourier Law's

$$\dot{Q} = kA\frac{T_1 - T_2}{L} \rightarrow k = \frac{\dot{Q}/A}{L(T_1 - T_2)}$$

$$\dot{Q} = kA\frac{(T_A - T_B)}{L} = -kA\frac{(T_B - T_A)}{L} = -kA\frac{dT}{dx}.$$

Where

Q = Heat flow rate in x- direction, unit in watt, Btu/hr

k = the thermal conductivity, unit in W/m.K, BTU/hr.ft.F

A = the area normal to the direction of heat flow, in unit m^2, ft^2

dT = different temperature (T_{low} - T_{high}), unit ^0C, ^0F

dx = thickness distance in the direction of heat flow. unit m^2, ft^2

3. Log Mean Different Temperature, ΔLMTD

$$\Delta T_{lm} = \frac{(\Delta T_2 - \Delta T_1)}{\ln(\Delta T_2/\Delta T_1)} \quad (2\text{-}2)$$

where:

ΔT_2 = the larger temperature difference between the two fluid streams at either the entrance or the exit to the heat exchanger

ΔT_1 = the smaller temperature difference between the two fluid streams at either the entrance or the exit to the heat exchanger

$$Q = U \cdot A \cdot \Delta T_{LMTD}$$

where

Q = heat transfer rate (W)

U = overall heat transfer coefficient ($W/m^2.K$) @ Correction Factor, F

A = area (m^2)

$\Delta LMTD$ = log mean temperature difference (K)

4. NEWTON Law's

$$P = \frac{dQ}{dt} = hA\,(T - T_0)$$

$P = dQ/dt$ is rate at which heat is transferred in watt / Btu/hr

h = convection heat-transfer coefficient $W/m^2.C$ / (Btu/hr-ft2-°F)

A = exposed surface area m^2 / ft^2

T = temperature of the immersed object (surface) ^0C

T_0 = temperature of the fluid sufficiently far from the surface ^0C

5. Stefan Boltzman Law's

$\dot{Q} = \sigma A T^4$ and $$q = \varepsilon \sigma A\left(T_s^4 - T_\infty^4\right)$$

Where:

Q = heat transfer, Btu/hr or Kw

σ = *Stefan-Boltzman constant*

0.1714 x 10-8 Btu/hr-ft2.R^4 *and* = 5.676 x 10-8 W/m2.K^4

ε = emission

A = Area surface

$T^4 = (T_1 - T_2)$, T_1 = Temperature of the first body, K or ^{0}R

T_2 = Temperature of second body, K or ^{0}R

6. Heat transmission, $Q = A.\ U.\ (T_{out} - T_{in})$

Where,	A = Area of the wall surface,	m^2 or ft^2
	U = U-Value,	$W/m^2.C$ or BTu/(hr•°F• ft2)
	T_{out} = Temperature out,	°C or °F
	T = Temperature in,	°C or °F

7. U-Value factor

$$U = \frac{1}{\text{Total Thermal Resistance}}$$

$$U = \frac{1}{\sum R}$$

where ,

$$\sum R = R_o + R + R_i$$

$$= \frac{1}{h_o} + \frac{\Delta x}{K} + \frac{1}{h_i}$$

8. Number of transfer unit (NTU)

$$NTU \equiv \frac{UA}{C_{min}}$$

where , NTU = number of transfer unit in dimensionless parameter

U = Overall heat Transfer Coefficient

A = Area surface

C_{min} = depending the value of C_h and C_c , $C = mC_p$