NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY
BACHELOR OF ENGINEERING (HONS) DEGREE
Part Two Examination May 2006

TCE 2206 Heat Transfer Processes

Duration of Examination 3 Hours

Instructions to Candidates:
1. Answer ANY FIVE questions.
2. Each question carries equal marks.
3. Show all your steps clearly in your calculation.
4. Start the answers for each question on a new page.

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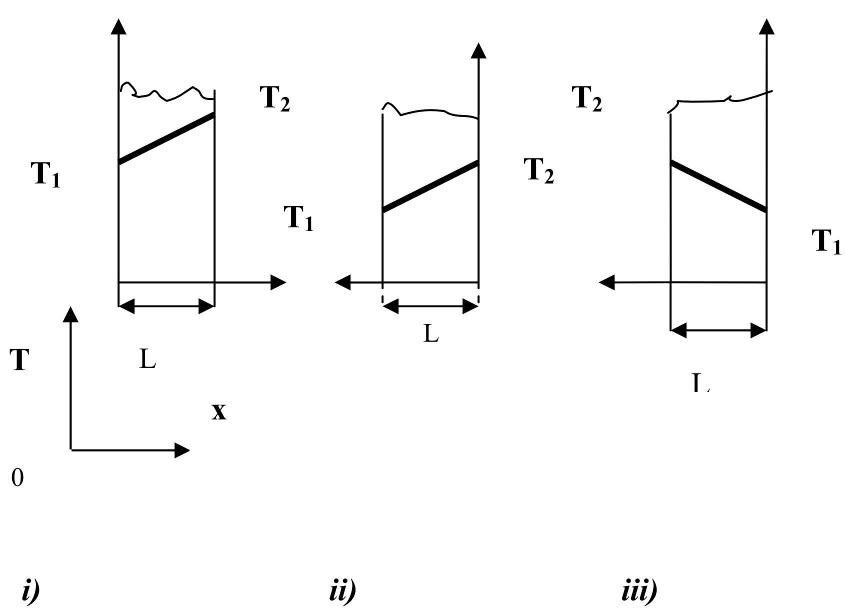
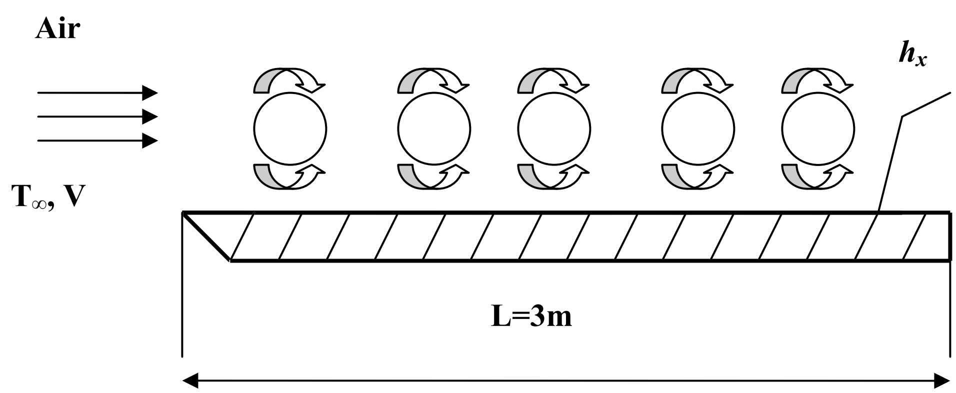
1. a) What are the three basic mechanisms of heat transfer?
Explain the mode of heat transfer in each of the three cases and give examples for each. (10 marks)

b) Consider a plane wall ***100 mm*** thick and of thermal conductivity ***100 W/m K***. Steady-state conditions are known to exist with $T_1 = 400\ K$ and $T_2 = 600\ K$. Determine the heat flux q_x'' and the temperature gradient dT/dx for the coordinate systems shown. (10 marks)

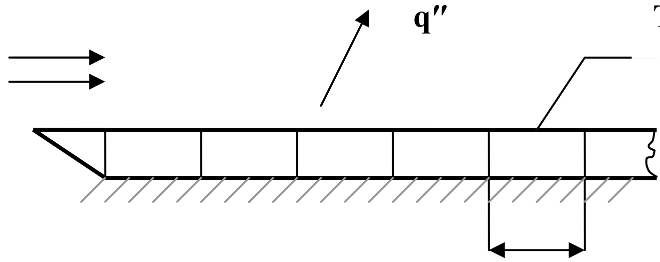


2. A cold storage room has walls made of ***220mm*** of brick on the outside, ***90 mm*** of plastic foam, and finally ***16 mm*** of wood on the inside. The outside and inside air temperatures are ***25°C*** and ***- 3°C*** respectively. If the inside and the outside heat transfer coefficients are respectively ***30*** and ***11*** $W/m^2 °C$, and the thermal conductivities of brick, foam and wood are ***0.99, 0.022*** and ***0.17 W/m°C*** respectively, determine:
   a) the rate of heat removal by refrigeration if the total wall area is $85m^2$.(10 marks)
   b) the temperature of the inside surface of the brick. (10 marks)

3. Parallel flow of atmospheric air over a flat plate of length ***L = 3m*** is disrupted by an array of stationary rods placed in the flow path over the plate. Laboratory measurements of the local convection coefficient at the surface of the plate are made for a prescribed value of V and $T_s > T_\infty$. The results are correlated by an expression of the form $h_x = 0.7 + 13.6x - 3.4x^2$, where h_x has units of W/m^2K and x is in ***meters***. Evaluate the average convection coefficient $\bar{h}_L$ for the entire plate and the ratio $\bar{h}_L / h_L$ at the trailing edge. (20 marks)



4. En electric air heater consists of a horizontal array of thin metal strips that are each ***10 mm*** long in the direction of an airstream that is in parallel flow over the top of the strips. Each strip is ***0.2 m*** wide, and ***25*** strips are arranged side by side, forming a continuous and smooth surface over which the air flows at ***2 m/s.*** During operation each strip is maintained at ***500°C*** and the air is at ***25°C***. What is the rate of convection heat transfer from the first strip? The fifth strip? The tenth strip? All the strips?



ΔL= 0.01

<u>**Take**</u>: Air (T_f = 535 K, 1 atm): ν= 43.54 · 10^{-6} m^2/s, K = 0.0429 W/m·K, Pr = 0.683
$Re_c = 5 \times 10^5$. (20 marks)

5. Velocity and temperature profiles for laminar flow in a tube of radius r_0= ***10 m***m have the form:
$u(r) = 0.1[1-(r/r_0)^2]$
$T(r) = 344.8 + 75.0(r/r_0)^2 - 18.8(r/r_0)^4$ with units of ***m/s*** and ***K***, respectively.
Determine corresponding values of the mean (or bulk) temperature, T_m, at this axial position. (20 marks)

6. Water at ***225 kg/h*** is to be heated from ***35*** to ***95°C*** by means of a concentric tube heat exchanger. Oil at ***225 kg/h*** and ***210°C***, with a specific heat of ***2095 J/kg K***, is to be used as a hot fluid. If the overall heat transfer coefficient based on the outer diameter of the inner tube is ***550 W/m² K***, determine the length of the exchanger if the outer diameter is ***100 mm***. The heat exchanger is operating in counter flow.
(20 marks)

Take : $c_{p,c}$ = 4188 J/kg K