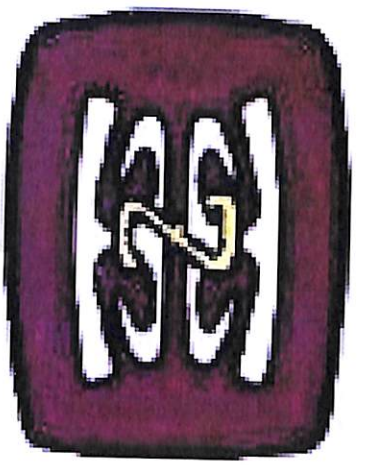
PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY
DEPARTMENT OF MECHANICAL ENGINERING

EXAMINATION QUESTION PAPERS



ME 313
HEAT TRANSFER

SEMESTER ONE – 2024

BY GK

THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

Department of Mechanical Engineering

ME313: Heat Transfer for Third Year Mechanical Engineering

Final Exam

Semester 1

Wednesday, May 29, 2024

INSTRUCTION FOR STUDENTS

(1) TIME ALLOWED – THREE (3) HOURS

(2) TOTAL NUMBER OF QUESTIONS – FIVE (5) AND 4 PAGES

(3) ANSWER ALL QUESTIONS

(4) SHOW YOUR WORK CLEARLY. **FOR FULL CREDIT SHOW ALL STEPS**

(5) NOTES AND TEXT BOOKS ARE NOT ALLOWED. CALCULATORS ARE PERMITED IN THE TEST ROOM.

(6) WRITE YOUR NAME AND STUDENT NUMBER CLEARLY ON THE FRONT OF THE ANSWER BOOKLET

(7) THIS PAPER MAY BE RETAINED BY CANDIDATE

(8) TOTAL MARKS: 40

(9) MARKING SCHEME:

QUESTION 1	11	MARKS
QUESTION 2	6	MARKS
QUESTION 3	7	MARKS
QUESTION 4	6	MARKS
QUESTION 5	10	MARKS

ALL ANSWERS MUST BE WRITTEN IN INK.

QUESTION 1

A steel pipe of 100 mm bore and 7 mm wall thickness, carrying steam at 260°C, is insulated with 40 mm of a moulded high-temperature diatomaceous earth covering. This covering is insulated with 60 mm of asbestos felt. The heat transfer coefficients for the inside and outside surfaces are 550 and 15 $W/m^2\,K$,. respectively, and the thermal conductivity of steel, diatomaceous earth, and asbestos felt are 50, 0.09, and 0.07 $W/m\,K$, respectively. Use the information provided by following through the steps to calculate the following;

(a) The rate Q at which heat is lost by the steam per m length of pipe;

(b) The temperature T_o of the outside surface

11 MARKS

QUESTION 2

In a 25 mm diameter tube the pressure drop per m length is 0.0002 bar at a section where the mean velocity is 24 m/s, and the mean specific heat of the gas is 1.13 $kJ/kg\,K$.

Calculate the heat transfer coefficient (h) in $W/m^2\,K$?

6 MARKS

QUESTION 3

Calculate the heat transfer coefficient for water flowing through a 25 mm diameter tube at the rate of 1.5 kg/s, when the mean bulk temperature is 40°C. For turbulent flow of a liquid Nusselt number is given by

$$Nu = 0.0243\,Re^{0.8} \times Pr^{0.4}$$

where the characteristic dimension of length (l) is the tube diameter (d) and all properties are evaluated at mean bulk temperature, hence, the fluid thermal conductivity $k = 632 \times 10^{-6}\ W/m\,K$, kinematic viscosity of fluid $v_f = 0.001\,m^2/s$, dynamic viscosity $\mu = 651 \times 10^{-6}\ Pa.s$ and Prandtl (Pr) number is given as 4.3. At Reynolds number (Re) greater than 2100, the flows are treated as turbulent. Use the information provided to determine the following;

(a) Determine whether the flow is turbulent or laminar (show calculations)

(b) Calculate the heat transfer coefficient (h) in $kW/m^2\,K$?

7 MARKS

QUESTION 4

You are asked to determine the heat loss Q by natural convection per m length from a horizontal pipe of 150 mm diameter, the surface of which is at $277°C$ and the Prandtl number $Pr = 0.68$ is given. The room temperature is $17°C$. It has been shown that for a horizontal cylinder, the Nusselt number (Nu) is given by

$$Nu = 0.527(Pr)^{1/2}(Pr + 0.952)^{-1/4}(Gr)^{1/4}$$

where properties are evaluated at the surface temperature.

Take coefficient of cubical expansion β as $1/T$, where T is in kelvin K is the absolute temperature of the air. Follow through the steps to finally calculate the following;

a) Heat transfer coefficient (h) in $kW/m^2\,K$

b) State the equation for the heat loss (Q), use this equation to calculate the Heat loss per m length in W

6 MARKS

QUESTION 5

You are asked to design a Shell and Tube Heat Exchanger to raise a temperature of water flowrate of 3.783 kg/s at $37.78°C$ is heated to $54.44°C$ in a shell-and-tube heat exchanger. On the shell side one pass is used with water of mass flowrate of 1.892 kg/s as the heating fluid, entering the exchanger at $93.33°C$. The overall heat-transfer coefficient is $1419\,W/m^2\,°C$, and the average water velocity in the 1.905 cm diameter tubes is $0.366m/s$. Due to space limitations, the tube length must not be longer than 2.438 m. With this space restriction in mind, you are required to calculate the following;

(a) the number of tubes passes,

(b) the number of tubes per pass, and

(c) the length of the tubes, consistent with the restriction

NOTE: Use the two graphs provided to estimate ***Correction Factor*** to be used in the calculation

10 MARKS

Attachments: Graphs for Correction Factors