UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	THERMOFLUIDS
COURSE CODE	:	BNT 10403
PROGRAMME CODE	:	BNT
EXAMINATION DATE	:	JUNE / JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	i) ANSWER **TWO (2)** QUESTIONS ONLY FROM **SECTION A** ii) ANSWER **TWO (2)** QUESTIONS ONLY FROM **SECTION B**

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

SECTION A

Q1 (a) Using appropriate graph define Newtonian fluid. On the same graph, name and indicate **TWO (2)** examples of non-Newtonian fluids.

(5 marks)

(b) A 1.2 mm diameter tube is inserted into an unknown liquid whose density is 960 kg/m3, and it is observed that the liquid rises 5-mm in the tube, making a contact angle of 15°. Determine:

(i) Determine the surface tension of the liquid.

(7 marks)

(ii) Calculate the capillary rise of the liquid, if the liquid is kerosene with surface tension 0.028 N/m and density is 820 kg/m3.

(8 marks)

(iii) Would the capillary rise be greater in small or large diameter tube? Using appropriate diagram explain your answer.

(5 marks)

Q2 (a) A researcher claims that the average velocity in a circular pipe in fully developed laminar flow can be determined by simply measuring the velocity at $R/2$ (midway between the wall surface and the centerline). What is your opinion about the statement? Please explain.

(4 marks)

(b) Water at 10°C (ρ = 999.7 kg/m^3 and μ = 1.307 x 10^{-3} kg/m · s) is flowing steadily in a 0.20 cm diameter, 15 m long pipe. In the fully developed laminar flow region, the velocity at $R/2$ (midway between the wall surface and the centerline) is measured to be 1.8 m/s. Determine the velocity at the center of the pipe at the average velocity of the flow.

(5 marks)

(c) Water at 10°C (ρ = 999.7 kg/m^3 and μ = 1.307 x 10^{-3} kg/m · s) is flowing steadily in a 5 cm diameter, 30 m long pipe horizontal pipe made of stainless steel at a rate of 9 L/s as shown in **Figure Q2 (c).** Determine:

(i) the pressure drop
(ii) the head loss and
(iii) the pumping power requirement to overcome this pressure drop.

(12 marks)

(d) How does surface roughness affect the pressure drop in a pipe if the flow is turbulent? Explain using appropriate diagram.
(4 marks)

Q3 (a) Using appropriate diagram explain the development of the velocity boundary layer and profile of fluid flow in a circular pipe. Indicate the hydrodynamic entrance region and fully develop region.
(7 marks)

(b) The fluid in a typical piping system passes through various fittings and components that may interrupt the smooth flow.
(i) Compare the major and minor head losses.
(ii) Define and explain the minor loss coefficient h_L.
(7 marks)

(c) Two water reservoirs A and B at **Figure Q3(c)**, are connected to each other through a 40-m-long, 2-cm-diameter cast iron pipe with a sharp-edged entrance. The pipe also involves a swing check valve and a fully open gate valve. The water level in both reservoirs is the same, but reservoir *A* is compressed air while reservoir *B* is open to the atmosphere at 88 kPa. Take the water temperature to be 10°C. If the initial flow rate through the pipe is 1.2 L/s, determine.

(i) The average flow velocity;
(4 marks)

(ii) Reynolds number;
(3 marks

(iii) The absolute air pressure on top of reservoir A.
(4 marks)

SECTION B

Q4 (a) Sketch P-v diagrams for steam and label the pressure, specific volume, temperature clearly, and then specify the phase of each state (on the diagrams) based on the following conditions:

(i) P = 20 bar, T = 250°C,

(ii) T = 212.4°C, v = 0.09957 m^3/kg,

(iii) P = 10 bar, h = 2650 kJ/kg, and

(iv) P = 6 bar, h = 3166 kJ/kg.

(6 marks)

(b) A household refrigerator with a COP of 1.7 removes heat from the refrigerated space at a rate of 80 kJ/min. Determine:

(i) The electric power consumed by the refrigerator in kW, and

(ii) Rate of heat transfer to the kitchen air in kW.

(iii) Sketch the schematic diagram of the refrigerator systems, and

(iv) Explain how the refrigerator system works.

(12 marks)

(c) Refrigerant-134a enters the condenser of a residential heat pump at 800 kPa and 35°C at a rate of 0.018 kg/s, and leaves at 800 kPa as a saturated liquid. If the compressor consumes 1.2 kW of power, determine:

(i) COP of the heat pump, and

(ii) Rate of heat absorption from the outside air.

(7 marks)

Q5 (a) The power output of an adiabatic steam turbine is 6.5 MW. If the inlet and exit conditions of the steam are as indicated in **Figure Q5(b)**, calculate:

(i) The magnitude of Δh, Δke, and Δpe.

(ii) The work done per unit mass of the steam flowing through the turbine.

(iii) The mass flow rate of the steam.

(15 marks)

(b) A well-insulated shell-and-tube heat exchanger is used to heat water in the tubes from 20°C to 80°C at a rate of 5 kg/s. Heat is supplied by hot oil that enters the shell side at 180°C at a rate of 10 kg/s. Determine the rate of heat transfer in the heat exchanger and the exit temperature of oil.

[Take c_{p,H_2O} = 4.18 kJ/kg.°C and $c_{p,oil}$ = 2.30 kJ/kg.°C]

(10 marks)

Q6 (a) Using appropriate diagram explain the term '**heat sink**'.

(4 marks)

(b) Sketch a *P-v* diagram of a Carnot cycle, label accordingly and indicate the heat in (Q_{in}), heat out (Q_{out}) and net work done ($W_{net,out}$) during the process of Carnot cycle.

(6 marks)

(c) A Carnot heat engine receives heat from a reservoir at 900°C at a rate of 700 kJ/min and rejects the waste heat to the ambient air at 27°C as shown in **Figure Q6(c).** The entire work output of the heat engine are used to drive a Carnot refrigerator that removes heat from the refrigerated space at -5°C and transfers it to the same ambient air at 27°C. Determine

(i) The maximum heat transfer from cooled space.

(ii) The total rate of heat rejection to the ambient air.

(15 marks)

- END OF QUESTIONS-

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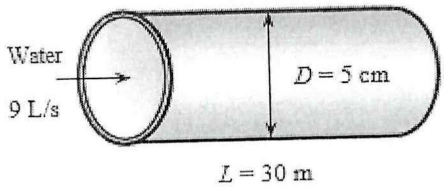

FIGURE Q2(c)

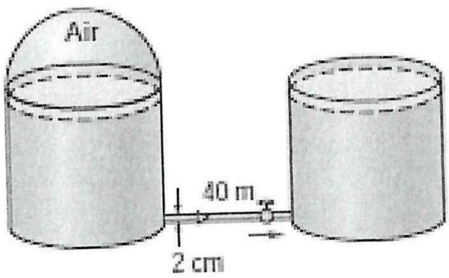

FIGURE Q3(b)

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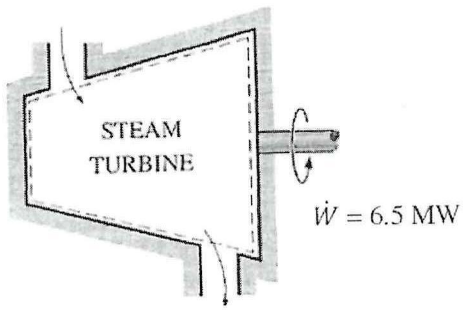
$P_1 = 2000$ kPa

$T_1 = 500°C$

$V_1 = 50$ m/s

$z_1 = 8$ m



$P_2 = 1750$ kPa

$x_2 = 88\%$

$V_2 = 180$ m/s

$z_2 = 5$ m

FIGURE Q5(a)

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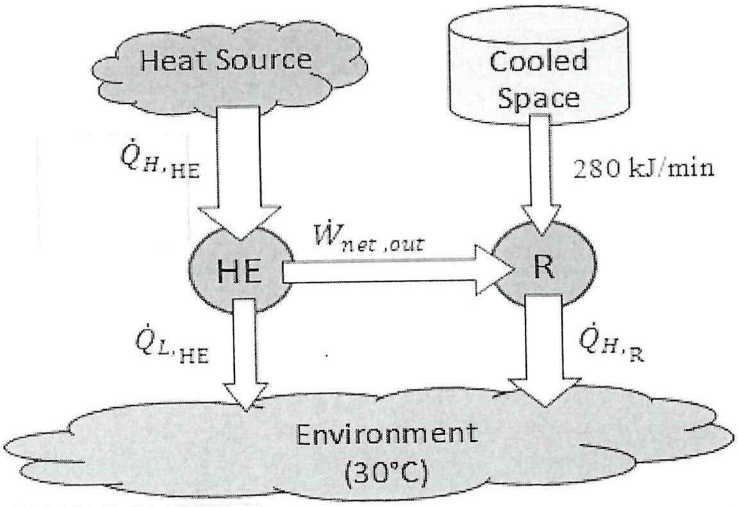

FIGURE Q6(c)