UTHM
Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER I
## SESSION 2022/2023

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|---|---|---|
| COURSE NAME | : | THERMOFLUIDS |
| COURSE CODE | : | BDU 10403 |
| PROGRAMME | : | BDC |
| EXAMINATION DATE | : | FEBRUARY 2023 |
| DURATION | : | 3 HOURS |
| INSTRUCTION | | 1. ANSWER **ALL** QUESTIONS IN **SECTION A** AND **TWO (2)** QUESTIONS IN **SECTION B** |
| | | 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.** |
| | | 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL SOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK. |

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

## SECTION A

**Q1** (a) Define and explain kinematics and fluid kinematic.

(4 marks)

(b) Brief basic types of line patterns to visualize flow are streamline patterns, path line, streak line and time line.

(4 marks)

(c) A steady, incompressible, two-dimensional velocity field is given by: (u,v) = (0.75 – 0.1x) i + (1.5 + 1.2y^2) j . Distinguish whether the location of the stagnation point exists or not?

(7 marks)

(d) The diagram in **Figure Q1(d)** shows a horizontal nozzle discharging into the atmosphere. The inlet has a bore area of 600mm$^2$ and the exit has a bore area of 200mm$^2$. When no energy loss and inlet pressure is 400 Pa, how much the flow rate exist?

(10 marks)

**Q2** (a) Determine the power required for a 1150-kg car to climb a 100-m long uphill road with a slope of 30° (from horizontal) in 12 s as shown in **Figure Q2(a)**

(i) at a constant velocity,
(ii) from rest to a final velocity of 30 m/s; and
(iii) from 35 m/s to a final velocity of 5 m/s. Disregard friction, air drag, and rolling resistance.

(15 marks)

(b) Large wind turbines with blade span diameters of over 100m are available for electric power generation. Consider a wind turbine with a blade span diameter of 100m installed at a site subjected to steady winds at 8m/s. Taking the overall efficiency of the wind turbine to be 32 percent and the air density to be 1.25 kg/m$^3$, determine the electric power generated by this wind turbine. Also, assuming steady winds of 8 m/s during a 24-hour period, determine the amount of electric energy and the revenue generated per day for a unit price of $0.09/kWh for electricity

(10 marks)

**SECTION B**

**Q3** (a) A househusband is cooking beef stew for his family in a pan that is

(i) uncovered;
(ii) covered with a light lid; and
(iii) covered with a heavy lid. For which case will the cooking time be the shortest? Why? Show illustration for each case.

(3 marks)

(b) What is the difference between the critical point and the triple point? Show the illustration diagram.

(2 marks)

(c) 100-kg of R-134a at 200 kPa are contained in a piston-cylinder device whose volume is 12.322m$^3$. The piston is now moved until the volume is one-half its original size. This is done such that the pressure of the R-134a does not change. Determine

(i) the final temperature; and
(ii) the change in the total internal energy of the R-134a.

(10 marks)

(d) Water initially at 200 kPa and 300°C is contained in a piston-cylinder device fitted with stops. The water is allowed to cool at constant pressure until it exists as a saturated vapor and the piston rests on the stops. Then the water continues to cool until the pressure is 100 kPa.

(i) On the T-v diagrams sketch, with respect to the saturation lines, the process curves passing through both the initial, intermediate, and final states of the water; and

(ii) Label the T, P and v values for end states on the process curves; and

Find the overall change in internal energy between the initial and final states per **unit** mass of water.

(10 marks)

**Q4** (a) Someone 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).

(i) what is your opinion about the statement, do you agree or not; and

(ii) explain your opinion.

(4 marks)

(b) A water tank located in a paint processing factory has two inlets and one outlet as shown in **Figure Q4(b)**. Steam at 2 bar, 95°C enters the first inlet at 5kg/s with a velocity of 30m/s. At the same time, saturated vapour at 5 bars enters the second inlet at 2 kg/s with a velocity of 50m/s. The heights of the first, second inlet and outlet are 25m, 10m and 5m respectively. If the velocity and pressure of the mixture at the outlet are 75m/s and 10bar respectively, determine:

(i) Temperature of the mixture at the outlet; and

(ii) Cross sectional area of each inlet and outlet. (Use equation below)

$$\dot{Q} - \dot{W} = \dot{m}_3\left(h_3 + \frac{1}{2}\bar{V}_3^2 + gz_3\right) - \left[\dot{m}_2\left(h_2 + \frac{1}{2}\bar{V}_2^2 + gz_2\right) + \dot{m}_1\left(h_1 + \frac{1}{2}\bar{V}_1^2 + gz_1\right)\right]$$

(9 marks )

(c) Water at 10°C ($\rho$ = 999.7 kg/m$^3$ and $\mu$ = 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 Q4(c).** Determine:

(i) the pressure drop;

(ii) the head loss; and

(iii) the pumping power requirement to overcome this pressure drop.

(12 marks)

**Q5** (a) An experimentalist claims to have raised the temperature of a small amount of water to 150°C by transferring heat from high-pressure steam at 120°C. Is this a reasonable claim? Why? Assume no refrigerator or heat pump is used in the process.

(5 marks)

(b) An adiabatic air compressor is to be powered by a direct-coupled adiabatic steam turbine that is also driving a generator. Steam enters the turbine at 12.5 MPa and 500°C at a rate of 25 kg/s and exits at 10 kPa and a quality of 0.92. Air enters the compressor at 98 kPa and 295 K at a rate of 10 kg/s and exits at 1 MPa and 620 K as shown in **Figure Q5(b)**. Determine the net power delivered to the generator by the turbine.

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

(ii) 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.

(8 marks)

**Q6** (a) 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.

(4 marks)

(b) A Carnot heat engine has thermal efficiency of 65%. This engine receives 650kJ of heat from a heat source at 600°C. Find
(i) Heat transfer to the ambient;
(ii) Temperature of the heat sink in °C; and
(iii) Net output of this engine in kJ.

(6 marks)

(c) An Engineer proposes a system of two Carnot Cycles, a heat engine and heat pump, to transfer heat from 400K to 500K and 300K, as shown in **Figure Q6(c)**. Examine if there any possible for heat engine has high and low temperatures of 400K and 300K, respectively by finding

(i) the rate of work supplied from combination heat engine and heat pump; and
(ii) appraise that Entropy change more than zero.

(15 marks)

**- END OF QUESTION -**

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**Figure Q1(d)**

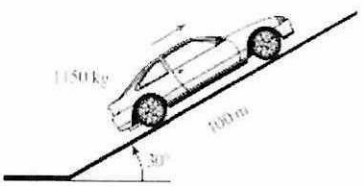


**Figure Q2(a)**

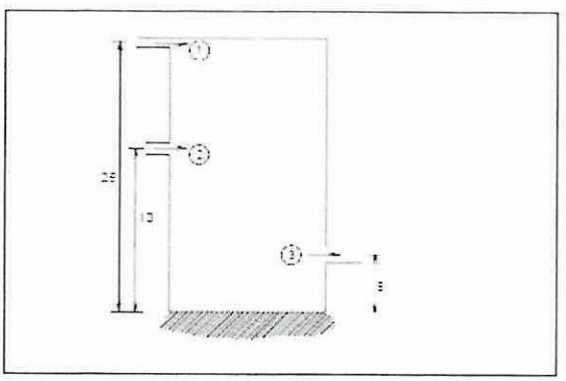


**Figure Q4(b)**

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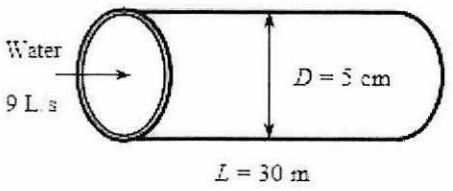


**Figure Q4(c)**

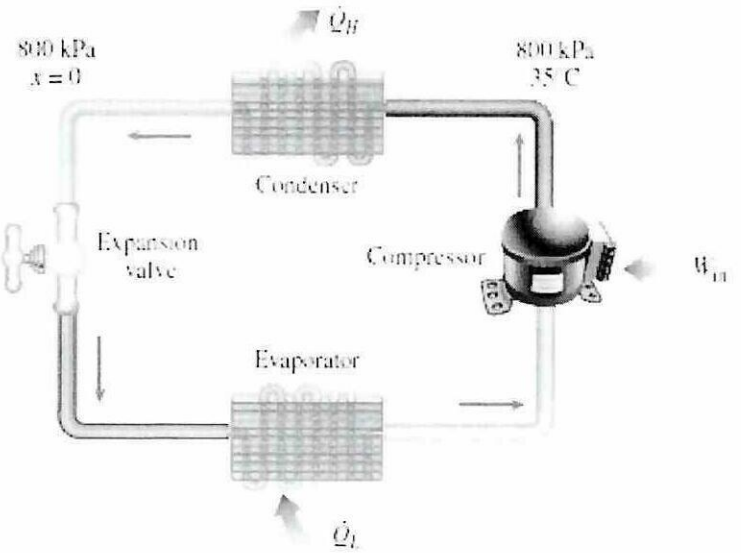


**Figure Q5(b)**

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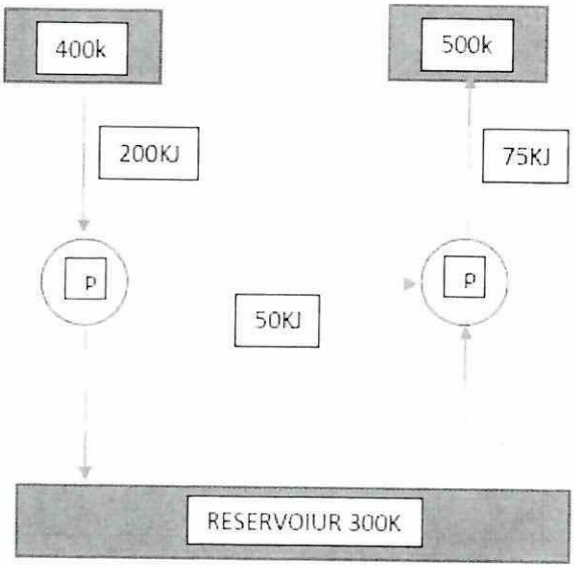


**Figure Q6(c)**