UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	THERMOFLUIDS
COURSE CODE	:	BDU 10403
PROGRAMME CODE	:	1 BDC / 1 BDM
EXAMINATION DATE	:	JUNE / JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **TWO (2)** QUESTIONS IN SECTION A AND **TWO (2)** QUESTIONS IN SECTION B

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

SECTION A

Q1 (a) A tank is filled with oil whose density is $\rho = 850$ kg/m^3. If the volume of the tank is V = 2 m^3, determine the amount of mass m in the tank.

(5 marks)

(b) A 4-ft-high, 3-ft-diameter cylindrical water tank whose top is open to the atmosphere is initially filled with water as shown in **Figure Q1(b)**. Now the discharge plug near the bottom of the tank is pulled out, and a water jet whose diameter is 0.5 in streams out. The average velocity of the jet is given by $\upsilon = \sqrt{2gh}$, where h is the height of water in the tank measured from the center of the hole and g is the gravitational acceleration. Determine how long it will take for the water level in the tank to drop to 2 ft from the bottom.

(10 marks)

(c) For the steady, incompressible, two-dimensional velocity field is expressed as

$$\vec{V} = (u, v) = (0.5 + 0.8x)\vec{\imath} + (1.5 - 0.8y)\vec{\jmath}$$

Analyse the field to obtain the equation of streamline at point (3,4).

(10 marks)

Q2 (a) Considera venturi with a throat-to-inlet area ratio of 0.8 mounted in a fluid flow at standard sea level conditions. If the pressure difference between the inlet and the throat is 7 lb/ft^2, calculate the velocity of the flow at the inlet. At standard sea level, take $\rho_{fluid} = 0.002377$ slug/ft^3.

(5 marks)

(b) Water flows over the fin of a small underwater vehicle at a speed of $V = 6.0$ mi/h. The temperature, density, and viscosity of the water is 40°F, 62.42 lbm/ft^3 and 1.038×10^{-3} lbm/ft·s, respectively. The chord length c of the fin is 1.6 ft. Analyse the boundary layer on the surface of the fin to determine whether it is laminar or turbulent or transitional. Justify your answer.

(10 marks)

(c) Air at 30°C with 1.164 kg/m^3 density and 1.872×10^{-5} kg/m.s viscosity flows at a uniform speed of 25 m/s along a smooth flat plate. Analyse the flow to obtain:

(i) x-location along the plate where the boundary layer begins the transition process toward turbulence.

(6 marks)

(ii) x-location along the plate where the boundary layer becomes fully turbulent. Justify your answer.

(4 marks)

Q3 (a) A vacuum gage connected to a chamber reads 5.8 psi at a location where the

atmospheric pressure is 14.5 psi. Determine the absolute pressure in the chamber.
(5 marks)

(b) Windmills in **Figure Q3(b)** slow the air and cause it to fill a larger channel as it passes through the blades. Consider a circular windmill with a 7-m-diameter rotor in a 10 m/s wind on a day when the atmospheric pressure is 100 kPa and the temperature is 20°C. The wind speed behind the windmill is measured at 9 m/s. Analyse the wind channel to obtain the power produced by this windmill, presuming that the air is incompressible.
(10 marks)

(c) In a hydroelectric power plant shown in **Figure Q3(c)**, 65 m^3/s of water flows from an elevation of 90 m to a turbine, where electric power is generated. The overall efficiency of the turbine-generator is 84 percent. Disregarding frictional losses in piping, estimate the electric power output of this plant.
(10 marks)

SECTION B

Q4 (a) Provide a brief explanation on the following laws:

(i) Zeroth law of thermodynamics
(2 marks)

(ii) First law of thermodynamics
(2 marks)

(iii) Second law of thermodynamics
(2 marks)

(b) 0.3 kg of air is at initial condition of 150kPa and 70°C. It undergoes series of processes such as the following:

Process 1-2: Isometric heating until the pressure is three times the initial pressure
Process 2-3: Isobaric heating until the volume is 2 times the initial volume.
Process 3-4: Polytropic expansion process with n = 1.35 until the pressure is reduced to 85 kPa

Determine:

(i) The pressure, temperature and volume of each process
(6 marks)

(ii) The total work and heat transfer
(4 marks)

Sketch the P-V diagram of the processes mentioned above. Take R = 0.287 kJ/kg.K, Cp = 1.005 kJ/kg, Cv = 0.718 kJ/kg and $\gamma = 1.4$.

(c) A piston cylinder system contains 2.4 kg of saturated water at 1.4 bar as shown in **Figure Q4(c)**. The water is heated until a portion of it evaporates and causes the piston to move upward. When the piston is at its constraint, the volume is 0.04 m^3. The heating is continued until its final pressure is twice its initial pressure. Determine:

(i) The fraction of saturated water at the end of the process.

(3 marks)

(ii) The final temperature.

(1 marks)

(iii) The total heat transfer.

(5 marks)

Q5 (a) Air enters an adiabatic turbine at 950kPa, 400°C with a velocity of 85m/s. It leaves the turbine at 140 kPa with velocity 160 m/s. The cross-sectional area of the inlet is 70 cm2. If power output of the turbine is 300 kW, determine the outlet temperature. State the assumption before analysis is carried out.

(7 marks)

(b) A water tank located in a paint processing factory has two inlets and one outlet. 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.

(6 marks)

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

(12 marks)

Q6 (a) Explain Claussius inequality and how it is used to determine the nature of a given process.

(5 marks)

(b) During winter, it is estimated that a typical single storey house will loose heat to the surrounding at 100,000 kJ/hour. To maintain the temperature of the house to 26°C, a heat pump is used. If the lightings and electronic appliances disperse 5,700kJ/hour and 30,500 kJ/hour of energy respectively, determine:

(i) The coefficient of performance of the heat pump if the power of the heat pump is 40,500 kJ/hour

(8 marks)

(ii) The rate of the heat transfer from the surrounding

(2 marks)

(c) A gas turbine operates with a simple Brayton cycle consist of a compressor, burner and turbine as shown in **Figure Q6(c)**. The compressor inlet temperature is 250 K and the turbine entry temperature is 1,750 K. The compressor pressure ratio is 40 and the inlet mass flow is 90 kg/s. Analyse the engine to obtain:

(i) The compressor and turbine powers.

(7 marks)

(i) The thermal efficiency.

(3 marks)

Sketch the Ts diagram. Take for air, $\gamma = 1.4$, CP =1.005 kJ/kg and, R = 0.287 kJ/kg.K.

- END OF QUESTIONS -

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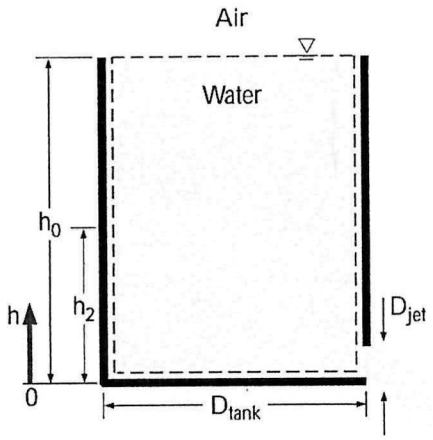

Figure Q1(b)

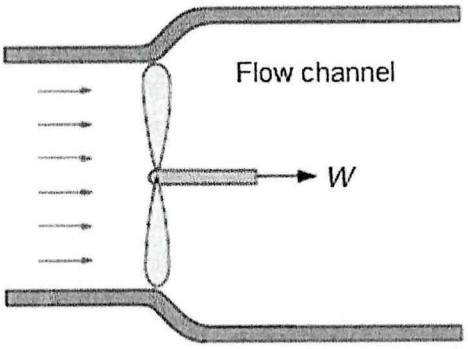

Figure Q3(b)

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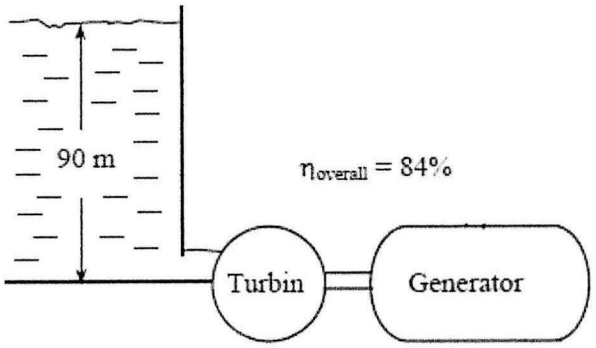

Figure Q3(c)

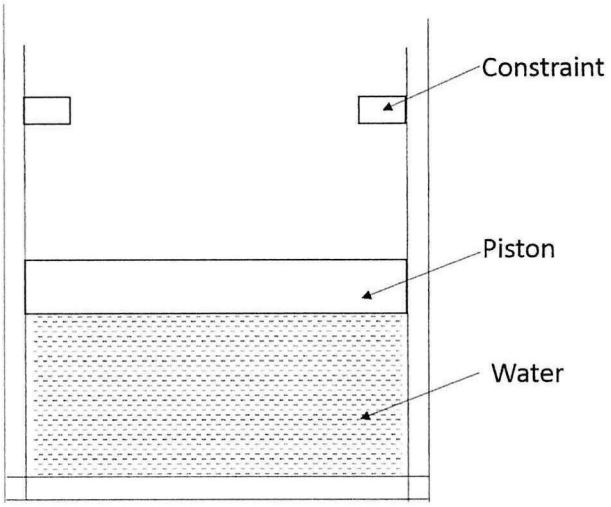

Figure Q4(c)

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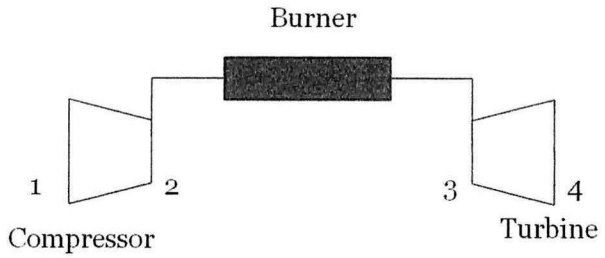

Figure Q6(c)