Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	FLUID MECHANICS
COURSE CODE	:	BDJ20203
PROGRAMME CODE	:	BDJ
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) Liquids are usually referred to as incompressible substances while gases on the other hand are highly compressible. Discuss the characteristics of these flows and relate your explanation with Mach Number.

(4 marks)

(b) At 60° latitude, the gravitational acceleration as a function of elevation z above sea level is given by $g = a\text{-}bz$, where $a = 9.807$ m/s^2 and $b = 3.28 \times 10^{-6}$ s^{-2}. Calculate the height above sea level where the weight of an object will decrease by 2%.

(4 marks)

(c) List out **TWO (2)** factors that will affect the surface tension

(2 marks)

(d) Describe the advantage of the inclined tube manometer.

(2 marks)

(e) An inclined tube manometer consists of a vertical cylinder 40 mm in diameter as shown in **Figure Q1.1**. At the bottom of this is connected a tube 4 mm in diameter inclined upward at an angle of 20° to the horizontal, the top of this tube is connected to an air duct. The vertical cylinder is open to the air and the manometric fluid has a relative density of 0.785. Determine the pressure in the air duct if the manometric fluid moved 50mm along the inclined tube.

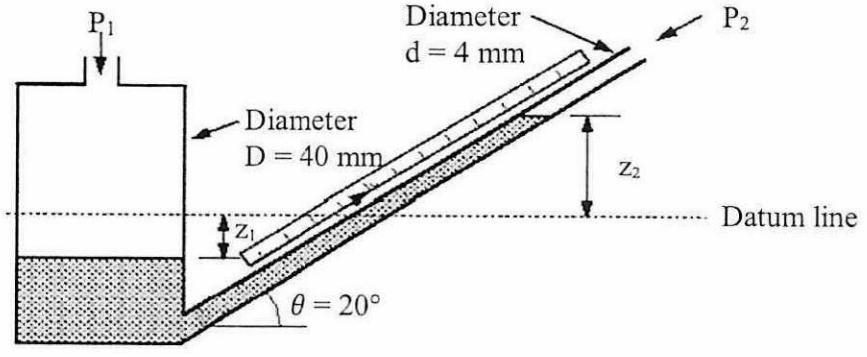

Figure Q1.1

(8 marks)

Q2 (a) Consider a large cubic ice block floating in seawater as shown in **Figure Q2.1**. The specific gravities of ice and seawater are 0.94 and 1.03, respectively. If a 10 cm high portion of the ice block extends above the surface of the water, estimate the height of the ice block below the surface.

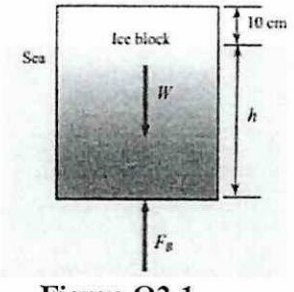

Figure Q2.1

(3 marks)

(b) When a ship is floating in still water, the pressure of water on the boat below the waterline pushes upward, creating a buoyant force. With an aid of a diagram, discuss the concept of stability of ships explaining the conditions when the ships can be considered in unstable equilibriums.

(4 marks)

(c) Briefly explain the concept of metacenter in determining the stability of a floating body.

(3 marks)

(d) State the **THREE (3)** major assumptions used in the derivation of the Bernoulli equation.

(3 marks)

(e) A pressurized tank of water has an 8 cm diameter orifice at the bottom, where water discharges into the atmosphere as shown in **Figure Q2.2**. The water level is 4 m above the outlet. The tank air pressure above the water level is 250 kPa (absolute) while the atmospheric pressure is 100 kPa. Neglecting frictional effects, calculate the initial discharge rate of water from the tank.

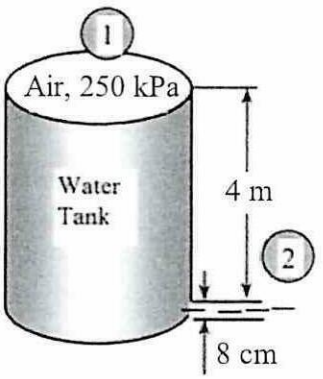

Figure Q2.2

(7 marks)

Q3 (a) Water is flowing through a venturi meter whose diameter is 12 cm at the entrance part and 4 cm at the throat as shown in **Figure Q3.1**. The pressure is measured to be 350 kPa at the entrance and 150 kPa at the throat. Neglecting frictional effects, calculate the flow rate of water.

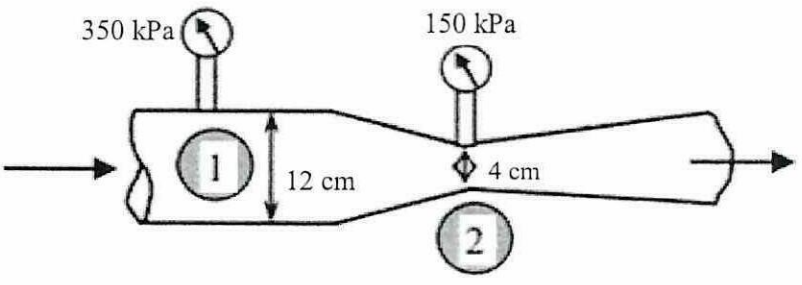

Figure Q3.1

(6 marks)

(b) State Newton's Second Law of Motion that relates to the conservation of momentum.

(2 marks)

(c) Water flows through a reducing 180° bend as shown in **Figure Q3.2**. Determine the magnitude of the force exerted on the bend in the x-direction. Assume energy losses to be negligible.

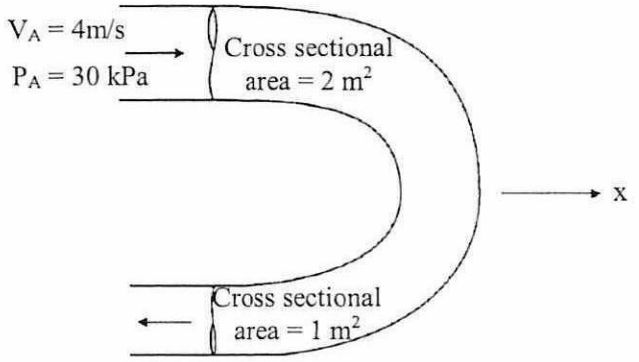

Figure Q3.2

(6 marks)

(d) Water accelerates by a nozzle to 50 m/s and strikes the vertical back surface of a cart moving horizontally at a constant velocity of 23 m/s in the flow direction as shown in **Figure Q3.3**. The mass flow rate of water through the stationary nozzle is 40 kg/s. After the strike, the water stream splatters off in all directions in the plane of the back surface. Estimate the force that needs to be applied by the brakes of the cart to prevent it from accelerating.

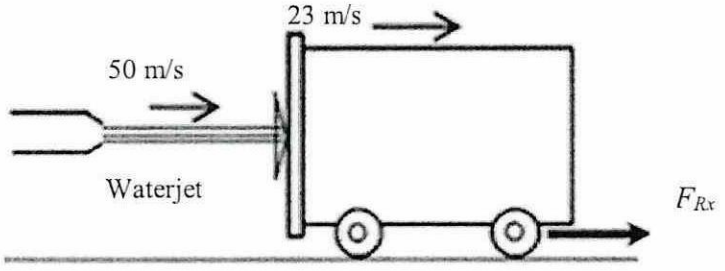

Figure Q3.3

(6 marks)

Q4 (a) Reynold number is the ratio of the inertial forces to viscous forces. Derive the Reynold number equation for rectangular shape air duct as shown in **Figure Q4.1**.

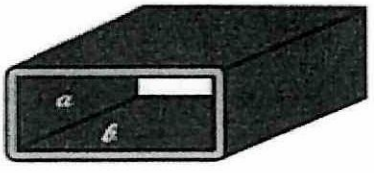

Figure Q4.1

(3 marks)

(b) The compressed air requirements of a manufacturing facility are met by a 120 hp compressor that draws in air from the outside through a 9 m long, 22 cm diameter duct made of thin galvanized iron sheets. The compressor takes in air at a rate of 0.27 m^3/s at the outdoor conditions of 15°C and 95 kPa. Disregarding any minor losses,

(i) State **THREE (3)** assumptions to solve this problem

(3 marks)

(ii) Determine the useful power used by the compressor to overcome the frictional losses in this duct. (Takes air at 1 atm = 101.3 kPa and 15°C are ρ = 1.225 kg/m3 and $\mu = 1.802 \times 10^{-5}$ kg/ms. The roughness of galvanized iron surfaces is ε = 0.00015 m). You may use the Moody Diagram provided to calculate the friction factor.

(14 marks)

Q5 (a) Pump is an energy absorbing device while the turbine is an energy-producing device. Discuss the purpose of each device and relate it with the fluid pressure and fluid speed.

(4 marks)

(b) A positive displacement pump moves a fluid by repeatedly enclosing a fixed volume and moving it mechanically through the system. The pumping action is cyclic and can be driven by pistons, screws, gears, rollers, diaphragms, or vanes. Sketch, **TWO (2)** examples of positive-displacement pumps.

(6 marks)

(c) The performance data of a water pump follow the curve fit $H_{available} = H_0 - aV^2$, where the pump's shutoff head H_0 = 7.46 m, coefficient a = 0.0453 m/(Lpm)^2. The pump is used to pump water from one large reservoir to another large reservoir at a higher elevation. The free surfaces of both reservoirs are exposed to atmospheric pressure. The system curve simplifies to $H_{required} = (z_2 - z_1) + bV^2$, where elevation difference $z_2 - z_1$ = 3.52 m, and coefficient b = 0.0261[m/(Lpm)^2.

(i) State **TWO (2)** assumptions for the working condition stated above.

(2 marks)

(ii) Calculate the operating point of the pump ($V_{operating}$ and $H_{operating}$) in appropriate units Lpm and meters unit.

(6 marks)

(iii) If the pump is required to deliver 9 Lpm, outline **TWO (2)** parameters need to be improved.

(2 marks)

-END OF QUESTIONS –

APPENDIX