Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	FLUID MECHANICS
COURSE CODE	:	BNJ20203
PROGRAMME CODE	:	BNG/BNH/BNK/BNL/BNM
EXAMINATION DATE	:	JUNE/JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) (i) Define the meaning of boundary layer.

(2 marks)

(ii) Distinguish the difference between laminar and turbulent flow.

(3 marks)

(b) Based on the definition of Mach number, explain about the phenomena of sonic boom.

(5 marks)

(c) A retaining wall against a mud slide is to be constructed by placing 1.2m high, 1m length, and 0.25m wide rectangular concrete blocks (ρ = 2700 kg/m^3) side by side, as shown in **Figure Q1 (c)**. The friction coefficient between the ground and the concrete blocks is f = 0.4, and the density of the mud is about 1400 kg/m^3, respectively. There is concern that the concrete blocks may slide or tip over the lower left edge as the mud level rises.

(i) Determine the mud height at which the blocks will overcome friction and start to sliding.

(8 marks)

(ii) Estimate the mud height to resist the blocks will tip over.

(2 marks)

Q2 (a) (i) Describe the term buoyancy and relate it with associated principle.

(3 marks)

(ii) Consider a standard basketball with mass of 624 grams and diameter of 24.3 cm is held fully under water. When released, the ball will float to the surface. Through the concept of buoyancy, interpret the occurrence of this phenomena and consequently, calculate the percentage of the ball that is below the water surface.

(7 marks)

(b) (i) Bernoulli's equation provides the relationship between pressure, velocity and elevation along a streamline. Outline **FOUR (4)** assumptions made in deriving the Bernoulli's equation.

(2 marks)

(ii) Differentiate each term in Bernoulli's equation for an incompressible flow as shown below.

$$\frac{P}{\rho g} + \frac{V^2}{2g} + z = C$$

where C is a constant along a streamline.

(3 marks)

(c) A pitot-static probe is inserted into the duct of an air heating system parallel to flow, and the differential height of the water column is measured as shown in **Figure Q2 (c)**. Determine the pressure rise at the tip of the Pitot-static probe and the flow velocity. The density of water and air is 1000 kg/m^3 and 1.074 kg/m^3 respectively.

(5 marks)

Q3 (a) A pressurized tank of water as shown in **Figure Q3 (a)** has a 10 cm diameter orifice at the bottom, where water discharge to the atmosphere. The water level is 2.5 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, determine the initial discharge rate of water from the tank.

(5 marks)

(b) Water accelerate by a nozzle to 35 m/s strikes the vertical back surface of a cart moving horizontally at a constant velocity of 10 m/s in the flow direction. The mass flow rate of water through the stationary nozzle is 30 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.

(5 marks)

(c) A Pelton wheel is used to produce hydroelectric power. The average radius of the wheel is 1.83 m, and the jet velocity is 102 m/s from a nozzle of exit diameter equal to 10.0 cm. The turning angle of the buckets is $\beta = 165°$.

(i) Calculate the volume flow rate through the turbine in m^3/s, and the optimum rotation rate in rpm of the wheel for maximum power

(8 marks)

(ii) Estimate the output shaft power in MW if the efficiency of the turbine is 82%.

(2 marks)

Q4 (a) Define net positive suction head and required net positive suction head. Explain how these two quantities are used to ensure that cavitation does not occur in a pump.

(4 marks)

(b) Sketch the working principle of **TWO (2)** types 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 **THREE (3)** assumptions of the fluid analysis and calculate the operating point of the pump ($V_{operating}$ and $H_{operating}$) in appropriate units Lpm and meters unit.

(8 marks)

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

(2 marks)

Q5 (a) (i) Define the meaning of entry length of the internal flow condition.

(2 marks)

(ii) Differentiate the approximation of entry length in laminar, transition and turbulent flow.

(6 marks)

(b) A vented tanker is to be filled with fuel oil with density is 920 kg/m^3 and kinematic viscosity is 0.045 kg/m·s from an underground reservoir using a 25 m long, 4 cm diameter plastic hose with a slightly rounded entrance and two 90° smooth bends as illustrated in **Figure Q5 (b)**. The elevation difference between the oil level in the reservoir and the top of the tanker where the hose is discharged is 5 m. The capacity of the tanker is 18 m^3 and the filling time is 30 minutes. Taking the kinetic energy correction factor at the hose discharge to be 1.05. Assuming an overall pump efficiency of 82 percent and neglecting the roughness factor of the hose, calculate the required power input to the pump.
(Given $K_{L,\ entrance} = 0.12$, and $K_{L,\ bend} = 0.3$)

(12 marks)

- END OF QUESTIONS -

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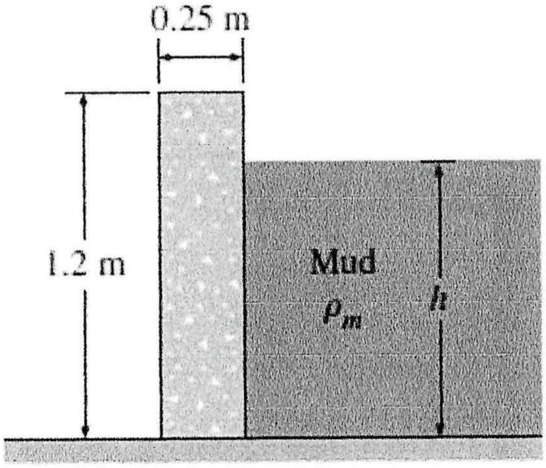

Figure Q1 (c)

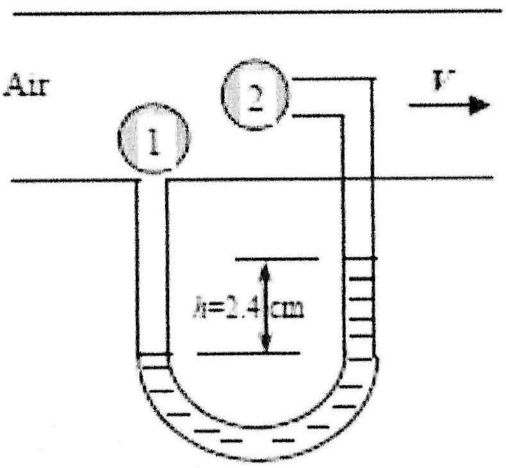

Figure Q2 (c)

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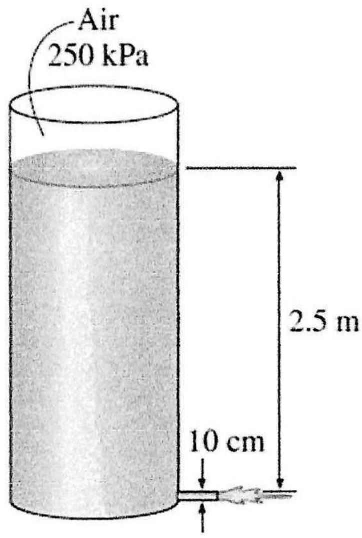

Figure Q3 (a)

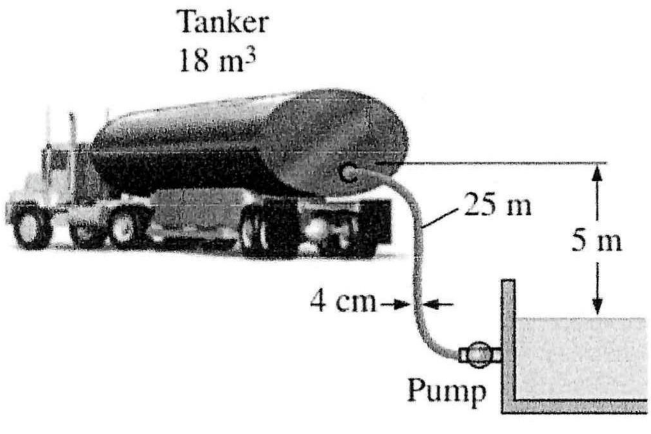

Figure Q5 (b)

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List of formula:

1. $Major\ loss, h_{f1} = \frac{f_1 l v^2}{2\ gD}$
2. $Minor\ loss, h_{L1} = \frac{K_{L1} v^2}{2\ g}$
3. Sudden enlargement, $K_{L2} = \left[1 - \left(\frac{D_1}{D_2}\right)^2\right]^2$
4. Colebrook equation, $\frac{1}{\sqrt{f}} = -2\ log\ (\frac{\varepsilon/D}{3.7} + \frac{2.51}{Re\sqrt{f}})$