UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	FLUID MECHANICS
COURSE CODE	:	BNQ 10304
PROGRAMME CODE	:	BNN
DATE	:	JUNE / JULY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

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

Q1 (a) Sketch a diagram to illustrate the gage pressure, absolute pressure, vacuum pressure and atmospheric pressure.

(5 marks)

(b) Explain why at higher elevation (mountain) the performance of the car is reduced and some people experiences shortness of breath.

(4 marks)

(c) A vacuum gage connected to a tank reads 30 kPa at a location where the barometric reading is 755 mmHg. Determine the absolute pressure in the tank. $S.G._{Hg} = 13.6$.

(6 marks)

(d) The basic barometer can be used to measure the height of a building. If the barometric readings at the top and the bottom of a building are 730 and 755 mmHg respectively, determine the height of the building. Assume an average air density of 1.18 kg/m^3.

(10 marks)

Q2 (a) Define pressure head, velocity head and elevation head for a fluid stream and express them for a fluid stream whose pressure is P, velocity is V and elevation is z.

(6 marks)

(b) Outline **THREE (3)** major assumptions used in the derivation of the Bernoulli's equation.

(6 marks)

(c) A pressurized tank of water has a 10 cm diameter orifice at the bottom, where water discharges 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. Refer to **Figure Q2 (c).**

(13 marks)

Q3 (a) Newton's laws of motion are three physical laws that laid the foundation for classical mechanics. They describe the relationship between a body and the forces acting upon it, and its motion in response to those forces.

(i) Define the first, second and third laws of Newton.

(6 marks)

(ii) Explain your understanding on **Q3 (a) (i)** by giving **ONE (1)** relevant example of each law.

(6 marks)

(iii) A rocket in space (no friction or resistance to motion) can expel gases relative to itself at some high velocity, V. Investigate if V is the upper limit to the rocket's ultimate velocity by relating it to the appropriate Newton's Law.

(3 marks)

(b) A horizontal 5 cm diameter water jet with a velocity of 18 m/s impinges normally upon a vertical plate of mass 1000 kg, refer **Figure Q3 (b)**. The plate rides on a nearly frictionless track and is initially stationary. When the jet strikes the plate, the plate begins to move in the direction of the jet. The water always splatters in the plane of the retreating plate. Assume that the velocity of the jet is increased as the cart moves such that the impulse force exerted by the water jet on the plate remains constant.

(i) Determine the acceleration of the plate when the jet first strikes it (time = 0)

(6 marks)

(ii) Calculate the time it takes for the plate to reach a velocity of 9 m/s.

(2 marks)

(iii) Predict the plate velocity 20 s after the jet first strikes the plate.

(2 marks)

Q4 (a) Hydraulic diameter is very important to determine the Reynolds number and the friction factor of a non-circular pipe.

(i) Define hydraulic diameter with related equations.

(2 marks)

(ii) If a diameter of a circular pipe is D. Interpret the equal hydraulic diameter for the respected pipe (show your equation/calculation).

(2 marks)

(iii) Explain why liquids are usually transported in circular pipes.

(2 marks)

(b) Reynolds number is defined as the ratio of inertial forces to viscous forces in the fluid. It is an important characteristic especially for internal flow in a circular pipe.

(i) Demonstrate that the Reynolds number for flow in a circular pipe of diameter D can be expressed as $Re = 4\dot{m}/\ (\pi D\mu)$.

(4 marks)

(ii) Identify **TWO (2)** reasons why friction factor is independent of the Reynolds number at very large Reynolds numbers.

(4 marks)

(c) Piping system *Gamma* and piping system *Beta* both have two pipes with different diameters (but identical length, material, and roughness) in which piping system *Gamma* is connected in series while piping system *Beta* is connected in parallel. Tabulate a comparison for the two different piping systems in terms of:

(i) the flow rates.

(4 marks)

(ii) the pressure drops.

(4 marks)

(d) Calculate the velocity at the center of the circular pipe with a fully developed laminar flow. Given the velocity at *R/2* (midway between the wall surface and the centerline) is measured to be 11 m/s with $u(r) = u_{max}\left[1 - \frac{r^2}{R^2}\right]$.

(3 marks)

Q5 (a) Hydraulic transport is the general name given to the transport of solid particles in liquid. Propose **FOUR (4)** most important categories of criteria variables with relevant examples that must be considered in estimating power consumption and pressure drops for a hydraulic transport system.

(8 marks)

(b) Multiphase flow is important in many industries of chemical and process engineering and the behavior of the material will depend on the properties of the components, the flow rates and the geometry of the system.

(i) Differentiate the characteristics between *vertical flow* and *horizontal flow*.

(4 marks)

(ii) Illustrate the flow pattern **EACH** for bubbly flow, plug flow, wavy flow and slug flow for the two phase gas-liquid system in horizontal pipe.

(4 marks)

(c) A solution of sodium hydroxide of density 1650 kg/m^3 and viscosity 50 mN.s/m^2 is agitated by a propeller mixer of 0.5 m diameter in a tank of 2.28 m diameter, and the liquid depth is 2.28 m. The propeller is situated 0.5 m above the bottom of the tank. Determine the power in which the propeller must impart to the liquids for a rotational speed of 2 rev/s. Refer **Figure Q5 (c)**.

(9 marks)

- END OF QUESTIONS -

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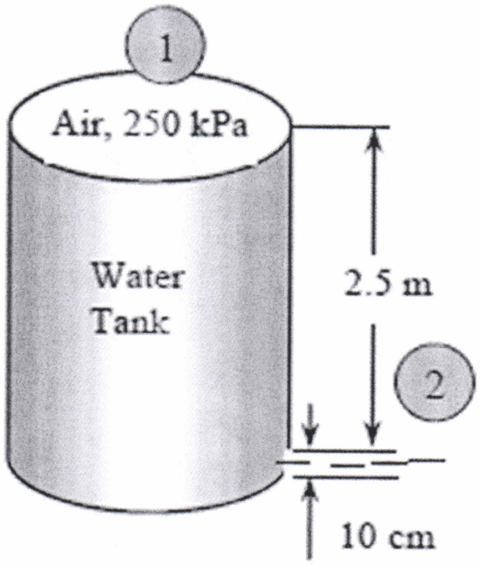

Figure Q2 (c)

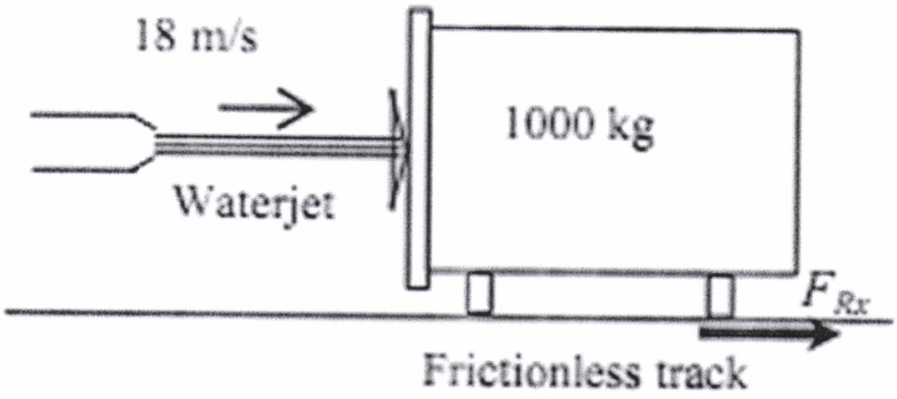

Figure Q3 (b)

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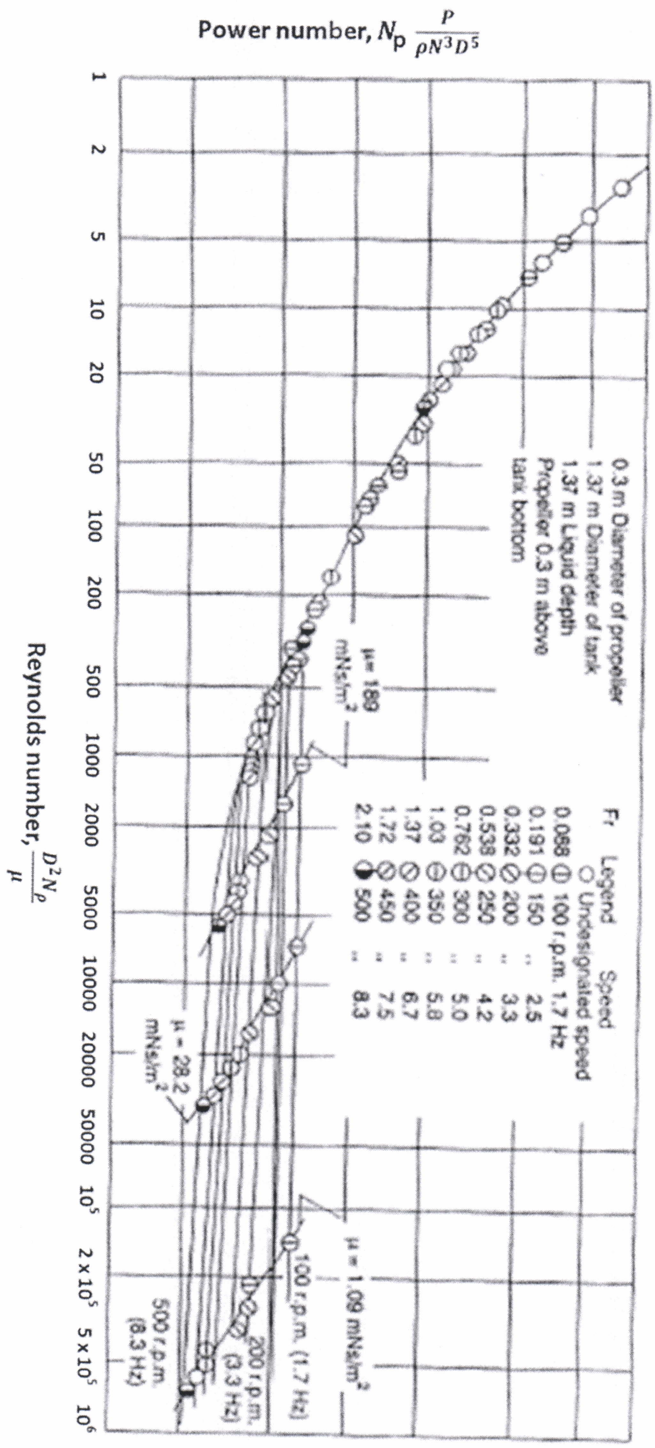

Figure Q5 (c)

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FORMULAE:

$$u(r) = u_{max}\left[1 - \frac{r^2}{R^2}\right]$$

$$m = \rho V A$$

$$F_{Rx} = -\dot{m}V$$

$$V_{plate} = V_{0,plate} + \alpha \Delta t$$

$$\mathrm{Re} = 4\dot{m} / (\pi D \mu)$$

$$R_e = \frac{VD}{v}$$

$$R_e = \frac{D^2 N \rho}{\mu}$$

$$F_r = \frac{N^2 D}{g}$$

$$N_p = \frac{P}{\rho N^3 D^5}$$

$$\mathrm{Re} = \frac{\text{Inertial forces}}{\text{Viscous forces}} = \frac{V_{avg} D}{\nu} = \frac{\rho V_{avg} D}{\mu}$$