Second Semester Examination
2021/2022 Academic Session

July/August 2022

EMH 222 – Fluid Dynamics
(Dinamik Bendalir)

Duration : 2 hours
(Masa : 2 jam)

Please check that this examination paper consists of FIVE (5) pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi LIMA (5) muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions : Answer **FIVE (5)** questions.

*[**Arahan**: Jawab **LIMA (5)** soalan.]*

1. (a) Describe the Newtonian and non-Newtonian fluids. Illustrate and label their shear stress – shear strain relationship in a simple graph.

(50 marks)

(b) A lubricating oil with a free stream velocity, U_s = 3.0 m/s, flows along a thin plate 1.5 m wide and 3.0 m long. Calculate:

(i) the shear stress at middle point of the plate.

(ii) the amount of skin friction on both sides of the plate.

Given: ρ_{oil} = 860 kg/m^3 , ν_{oil} = 10^{-5} m^2/s , $\tau_0 = 0.332\mu(U_s/x)Re_x^{0.5}$, $C_f = 1.33/Re_l^{0.5}$

(50 marks)

2. In a two-dimensional incompressible flow, the fluid velocity components are given by:

$$v_x = x - 3y \text{ and } v_y = -y - 3x.$$

(a) Show that the flow fulfils the continuity equation.

(20 marks)

(b) Derive the expression for the stream function.

(20 marks)

(c) Using differential method <u>or</u> Laplace's equation, prove that the flow is potential.

(20 marks)

(d) Derive the flow's velocity potential.

(20 marks)

(e) Calculate the values of stream function and velocity potential at a point (*0, 9*).

(20 marks)

3. (a) A person drives a car at a highway speed. Some of the power generated by the car's engine is used to overcome the drag. If the fuel consumption is nearly proportional to the drag force, calculate the percentage increase in fuel consumption of a car per unit time when a person who normally drives at 75 km/h now starts driving at 85 km/h.

(30 marks)

(b) A wind turbine has two 8-cm-diameter cups with a center-to-center distance of 25 cm is shown as Figure Q3 [b]. The wind turbine's pivot is stuck as a result of some failure, and the cups stop rotating. The wind speed is 15 m/s and the drag coefficient of hemispherical cup is 0.4 and 1.2 when the hemispherical and plain surfaces are exposed to wind flow. By considering the flow of air is steady and incompressible, calculate the maximum torque this turbine applies on the pivot. (Given the density of air is ρ= 1.25 kg/m^3.)

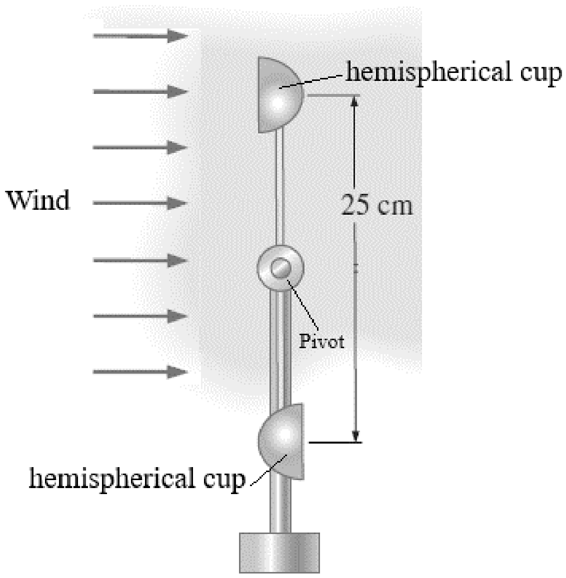

Figure Q3 (b)

(40 marks)

(c) Explain the flow separation phenomenon for laminar and turbulent flow over circular cylinders. Use sketch to support your answer.

(30 marks)

4. (a) Air flows through a close conduit with the stagnation pressure is 0.6 MPa, the stagnation temperature is 400°C, and the velocity is 570 m/s. By assuming the stagnation process is isentropic and the air is an ideal gas, calculate the static pressure and temperature of the air at this state.

(40 marks)

(b) Air flowing through a nozzle experiences a normal shock at a velocity 710 m/s, pressure 23.4 kPa and temperature 219 K. By assuming the flow through the nozzle is steady, one-dimensional, and isentropic before the shock occurs, calculate,

(i) The stagnation temperature and pressure upstream the shock

(ii) The Mach number upstream the shock

(iii) The stagnation pressure, pressure, temperature, and air velocity downstream the shock.

(Given the air properties at room temperature, k = 1.4, R = 0.287 kJ/ kg.K, and c_p = 1.005 kJ/ kg.K)

(60 marks)

5. (a) Sketch Figure Q5(a) on your answer sheet, label the SIX (6) terms on the diagram and explain them

(30 marks)

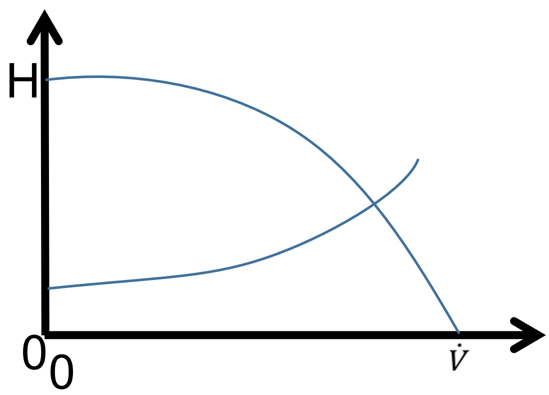

Figure Q5 (a)

(b) You are designing a landscape waterfall for your house as in Figure Q5 [b], its pumping system pumps from the pond to a water fall tank. Both pond and tank are exposed to atmospheric pressure. Given, friction factor, f = 0.04, pipe diameter, D = 2.5cm, length of pipe, L = 15m, pipe roughness, ε = 0.003, pump rotational speed, $\dot{n}$ = 2500 rpm, $K_{L,\ entrance}$ = 0.4, $K_{L,\ valve}$ = 3.0, $K_{L,\ elbow}$ = 0.3, $K_{L,\ exit}$ = 1.0, and $\dot{V}$ = 20 Lpm.

Given,

$$H_{required} = h_{pump,u} = \frac{P_2 - P_1}{\rho g} + \frac{\alpha_2 V_2^2 - \alpha_1 V_1^2}{2g} + (z_2 - z_1) + h_{L,total}$$

$$\textit{Pump specific speed, } N_{sp} = \frac{\omega \dot{V}^{\frac{1}{2}}}{(gH)^{\frac{3}{4}}}$$

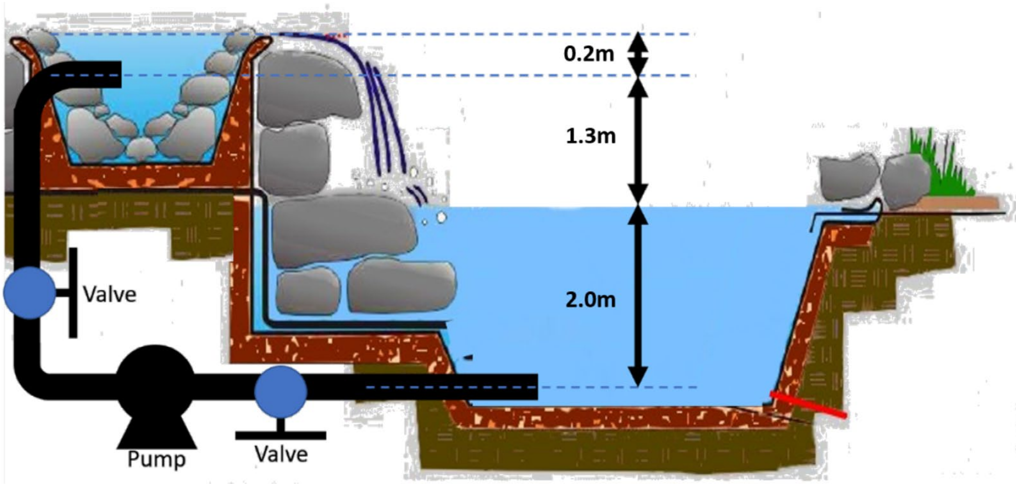

Figure Q5 (b)

Calculate*:*

i. the sum of all minor loss coefficients,

ii. the total head loss,

iii. the required pump head*,*

iv. the pump specific speed,

(70 marks)

- oooOOOooo -