Second Semester Examination
2020/2021 Academic Session

July/August 2021

EMH 222 – Fluid Dynamics *[Dinamik Bendalir]*

Duration: 3 hours

Please check that this paper contains **FOUR (4)** printed pages and **TEN (10)** questions before you begin the examination.

INSTRUCTIONS: Answer **ALL** questions.

Answer questions in English OR Bahasa Malaysia.

Answer to each question must begin from a new page.

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

(20marks)

2. Oil with a free stream velocity, U_s = 3.** m/s, flows along a thin plate 1.25 m wide and 2 m long. Calculate:

   (i) the shear stress at mid length of the plate.
   (ii) total, double-sided skin friction of the plate.

   Given: ρ_{oil} = 860 kg/m^3, ν_{oil} = 10^{-5} m^2/s, $\tau_0 = 0.332\mu(U_s/x)Re_x^{0.5}$, $C_f = 1.33/Re_l^{0.5}$
   NOTE: U_s = 3.** m/s - ** refers to last two digits of your matric number.

(50 marks)

3. Summarize and compare the use of computational fluid dynamics (CFD) methods that incorporate relevant mathematical formulas in solving complex problems in fluid flows. Give your opinion on the accuracy of the CFD results compared with experimental results.

(30 marks)

4. A counter balance with a mass of 2 kg balances the weight of a thin flat plate 60 cm × 60 cm, as shown in Figure Q4. When the blower is turned on, air at 1 atm and 25^{o}C flows downhill over both surfaces of the plate at a free stream velocity of 15 m/s. By assuming the flow is steady and incompressible, calculate the mass of the counter balance that will be required to keep the plate balanced in this case.

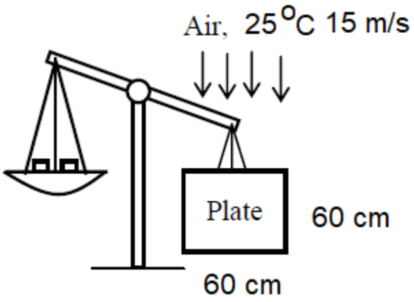

Figure Q4

(30 marks)

5. With a cruising drag coefficient, C_D of 0.03 and a mass of 65 000 kg, a commercial passenger aircraft with a wing area of 350 m^2 is flying at an altitude of 12 000 m. If the aircraft maximum lift coefficient, $C_L$max is 3.2 at standard atmospheric condition, calculate:

   (i) The takeoff speed at sea level if the takeoff speed is 25% over the stall speed.
   (ii) The thrust provided by engines for a cruising speed of 800 km/h.

   (Given: air density at sea level = 1.225 kg/m3, air density at 12 000 m altitude = 0.312 kg/ m3)

(20 marks)

6. At a temperature of 300 K and a pressure of 2.5 MPa, air in a supersonic wind tunnel flows at a low velocity via a converging-diverging nozzle. At the exit nozzle, the normal shock wave occurs at Mach number, Ma= 2.5. Calculate the Mach number, pressure, temperature, and velocity downstream the shock

   (Assuming the air is an ideal gas with constant specific heats and the flow is steady).

(30 marks)

7. Using a sketch, give TWO differences between and normal shock wave and oblique shock

(20 marks)

8. Based on your understanding, what is a positive displacement machine? Give one example and explain the operation of the given example. (WARNING: plagiarism will be given 0 marks)

(10 marks)

9. Based on your understanding, what is a dynamic machine? Give one example and explain the operation of the given example. (WARNING: plagiarism will be given 0 marks)

(10 marks)

10. Vertical savonius wind turbine (as shown in Figure Q10) was used to generate electricity. The pressure that exerted on the blades are 230 Pa (convex) and 440 Pa (concave), respectively, when the cups are normal to the wind. The diameter of the blade, d is 50 cm, diameter of the turbine, D is 95cm, and the height of the turbine, H is 100 cm. Given that the C_D for convex and concave are 1.2 and 2.3, respectively; the r_{air} is 1.25 kg/m^3; efficiency of gearbox and generator is 88%, and power coefficient of 0.2. Calculate:

    (i) force on blade convex surface;
    (ii) force on blade concave surface;
    (iii) average wind speed;
    (iv) available wind power;
    (v) electrical power production;
    (vi) compare (iii) with output that achieve Betz limit

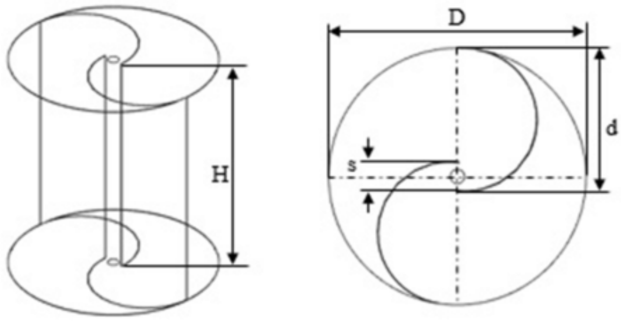

Figure Q10 Savonius wind turbine

(30 marks)

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