BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI, HYDERABAD CAMPUS

FIRST SEMESTER 2022-2023

Mid-Semester Examination (Closed Book- Regular)

Course No: CE F 312, Time: 3.30-5.00 am

Course Title: HYDRAULIC ENGINEERING

Date: 2.11.2022, Max. Marks: 25, Duration: 90 Minutes

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1. Answer all four questions.
2. Answer each question on a fresh page.
3. The students shall not resort to any unfair means in attempting the exam. The consequences of adopting unfair means will be severe.

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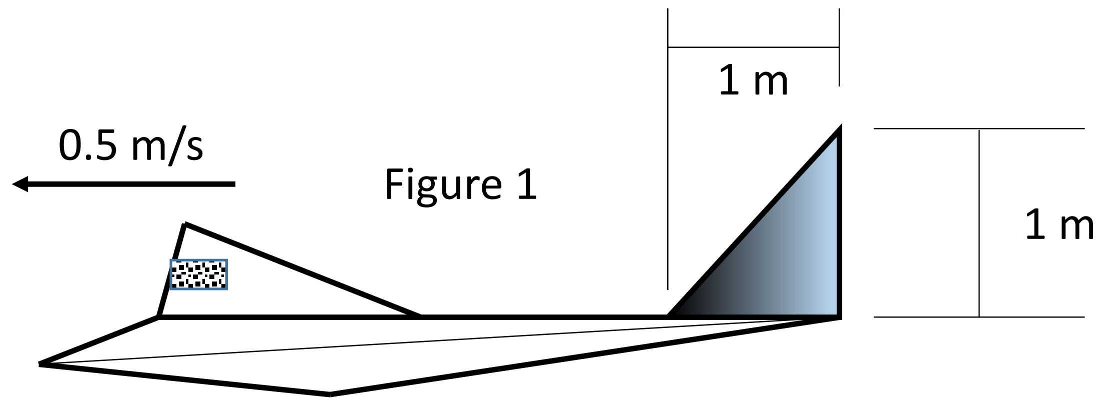
1. A small submarine has a triangular stabilizing fin on its stern with the dimensions shown in Figure 1. If $\rho = 999.2$ kg/m^3, $\nu = 1.15 \times 10^{-6}$ m^2/s for water at temperature 15^{0}C, determine the drag on the fin when the submarine is traveling at 0.5 m/s.



(7 Marks)

2. A rough pipe with a diameter of 25 cm and a length of 1000 m is carrying water at 20^{0}C at a flow rate of 100 liters/s. The average height of the roughness projections on the pipe surface is 0.25 mm. Find the (a) friction factor, (b) shear stress at the pipe surface, (c) shear/friction velocity, and (d) maximum velocity. At 20^{0}C, the density of water is 1000 kg/m^3 and kinematic viscosity is 1×10^{-6} m^2/s. (e) If you assume the pipe to be smooth (for example, the roughness height of projections is not given as above), how much less power is required to maintain the flow compared to the rough pipe as given above with other conditions being the same? **(7 Marks)**

3. Water flows in a channel of the shape of an isosceles triangle of bed width *b* and sides making an angle of 45^0 with the bed. Determine the relationship between the depth of flow *y* and the bed width *b* for maximum velocity condition and for maximum discharge condition. Use Manning's formula and note that $y < 0.5$ b. **(7 Marks)**

4. A 220 mm diameter, 2200 m long, steep pipe with a 3.1 m/s water flow velocity has a valve at the end. 14 seconds later, the valve closes. How much pipe pressure is produced? Consider that the pressure wave's velocity is 1250 m/s. What will the increase in pipe pressure be if the valve is closed in 1.4 seconds? The wall of the pipe is 12 mm thick. The bulk elastic modulus for water is 2.1 X 10^9 N/m^2, while the modulus of elasticity for steel is 2.1 X 10^{11} N/m^2. **(4 Marks)**

Formulae sheet

$$\frac{\delta}{x} = \frac{5}{\sqrt{Re_x}};\ c_f = \frac{\tau_0}{\frac{\rho V^2}{2}} = \frac{0.664}{\sqrt{Re_x}};\quad \frac{\delta^*}{x} = \frac{1.729}{\sqrt{Re_x}};\ \frac{\theta}{x} = \frac{0.664}{\sqrt{Re_x}};\ C_f = \frac{1.328}{(Re_L)^{\frac{1}{2}}}$$

$$\frac{\delta}{x} = \frac{0.376}{(Re_x)^{\frac{1}{5}}};\ c_f = \frac{0.059}{(Re_x)^{\frac{1}{5}}};\ C_f = \frac{0.074}{(Re_L)^{\frac{1}{5}}};\ C_f = \frac{0.455}{(log_{10}Re_L)^{2.58}};\ C_f = \frac{0.074}{(Re_L)^{\frac{1}{5}}} - \frac{1700}{Re_L};\ C_f = \frac{0.455}{(log_{10}Re_L)^{2.58}} - \frac{A}{Re_L};\ \delta' = \frac{11.6\nu}{V*};\ \frac{\tau_0}{\rho V^2} = \frac{d\theta}{dx};$$

$$\frac{v_{max}-v}{V*} = 5.75log_{10}\left(\frac{R}{y}\right);\ \frac{v}{V*} = 5.75log_{10}\left(\frac{V_* y}{\nu}\right) + 5.5$$

$$\frac{v}{V*} = 5.75log_{10}\left(\frac{y}{k}\right) + 8.5;\ \frac{V}{V*} = 5.75log_{10}\left(\frac{V_* R}{\nu}\right) + 1.75$$

$$\frac{V}{V*} = 5.75log_{10}\left(\frac{R}{k}\right) + 4.75;\ f = \frac{64}{Re};\ \ f = \frac{0.316}{(Re)^{1/4}};\ \ f = 0.0032 + \frac{0.221}{(Re)^{0.237}}$$

$$\frac{1}{\sqrt{f}} = 2.0log_{10}\left(Re\sqrt{f}\right) - 0.8;\ \frac{1}{\sqrt{f}} = 2.0log_{10}\left(\frac{R}{k}\right) + 1.74$$

$$\frac{1}{\sqrt{f}} - 2.0log_{10}\left(\frac{R}{k}\right) = 1.74 - 2.0log_{10}\left(1 + 18.7\frac{R/k}{Re\sqrt{f}}\right)$$