UCE-305 FLUID MECHANICS

Tutorial No. 10 (Dimensional Analysis)

Q1: The equation, $\mathbf{P = 2.67\sqrt{Q}}$ is applicable in **FPS** units, where **P** is the wetted perimeter and **Q** is the discharge. Modify this equation for **SI** units.

Q2: Derive an expression for discharge **Q** flowing through an orifice which is dependent on diameter of the orifice **D**, pressure difference $\Delta\mathbf{p}$ and density of fluid $\boldsymbol{\rho}$.

Q3: The critical depth $\mathbf{y_c}$ in a triangular channel depends upon discharge **Q**, acceleration due to gravity **g** and vertex angle $\boldsymbol{\theta}$**.** Using a method of dimensional analysis, obtain expression for critical depth.

Q4: The pressure difference $\Delta\mathbf{p}$ in a pipe depends upon diameter **D**, length **L,** velocity **V,** viscosity $\boldsymbol{\mu}$, density $\boldsymbol{\rho}$ and roughness **k**. Using Buckingham's method, obtain an expression for $\Delta\mathbf{p}$. Hence derive expression for head loss $\mathbf{h_f}$ in the standard form**.**

Q5: The resistance **R** experienced by a completely submerged body depends upon relative velocity **V**, length **L**, viscosity $\boldsymbol{\mu}$**,** and density $\boldsymbol{\rho}$**.** Using Buckingham's method, express this relationship in dimensionless form. If resistance of a $1/8^{th}$ scale air ship model when tested in water at 12 m/s is 215 N, what will be the resistance in air of an air-ship at the corresponding speed? Given, kinematic viscosity of air is 13 times that of water and density of water is 810 times that of air.

Q6: A venturimeter of diameter 0.75 m, fixed in a pipe of diameter 1 m carries water at 1.6 m^3/s. If performance of this venturimeter is to be tested on 1**:**5 scale model using air as a fluid, determine the model discharge. Given, $\boldsymbol{\nu_p} = 10^{-6}\ m^2/s$ and $\boldsymbol{\nu_m} = 1.5 \times 10^{-6}\ m^2/s$.

Q7: A test for frictional resistance was conducted on a pipe model 15 mm in diameter and 3 m long with water flowing through it. The head loss was found to be 7 m. The prototype is 300 mm in diameter and 240 m long through which air is flowing at 3.6 m/s. Find the speed of water in the model and pressure drop in the prototype. Given, $\rho_{water} = 1000\ kg/m^3$, $\rho_{air} = 1.22\ kg/m^3$; $\mu_{water} = 0.01$ Poise, $\mu_{air} = 1.8 \times 10^{-4}$ Poise.

Q8: A 7.2 m high and 15 m long spillway discharges 94 cumec under a head of 2.3 m. If 1:9 scale model of this spillway is to be constructed, determine model dimensions, head over the model and model discharge. If model experiences a force of 7.5 kN, determine the force on the prototype.

Q9: A model of an open channel is constructed to a scale of 1:100. If model has a Manning's roughness coefficient as 0.013, determine the prototype roughness coefficient.

Q10: An open channel model is constructed with a horizontal scale ratio of 1:100 and a vertical scale ratio of 1:25. What will be the bed slope in the model if bed slope of the prototype is 1 in 1000? Also, calculate the corresponding roughness scale ratio.

Answers:

Q1: $P = 4.84\sqrt{Q}$; **Q2:** $Q = KD^2\sqrt{\frac{\Delta p}{\rho}}$; **Q3:** $y_c = K\left(\frac{Q^2}{g}\right)^{1/5}$; **Q4:** $\Delta p = \rho V^2 \phi\left(\frac{L}{D}, \frac{\mu}{\rho VD}, \frac{k}{D}\right)$;

Q5: $R = \rho L^2 V^2 \phi\left(\frac{\mu}{\rho VL}\right)$; **44.86 N** **Q6:** **0.48 m^3/s;** **Q7: 4.88 m/s, 0.182 kN/m^2;**

Q8: 1.67 m, 0.25 m, 0.8 m, 0.387 m^3/s, 5463.5kN; Q9: 0.028; Q10:1/250, 0.041