SOLUTION (Class Test - I)

Subject: Hydraulics & OCF
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Q-1. Rigid boundary channel

Q-2 $\frac{P}{\gamma} + Z$ (Pressure head + Datum head)

Q-3. (a)

$$Q \propto S^{1/2}$$

$$\frac{Q_1}{Q_2} = \sqrt{\frac{S_1}{S_2}} = \sqrt{\frac{0.0009}{0.0001}}$$

$$\frac{30}{Q_2} = 3$$

$$\boxed{Q_2 = 10 \ m^3/s}$$

Q-4 (2)

$$\frac{B}{y_e} = 2$$

Q-5. (d)

$$\frac{\delta}{x} = \frac{0.316}{(R_{ex})^{1/5}}$$

$$\delta \propto \frac{x}{x^{1/5}} \propto x^{4/5}$$

$$\boxed{\delta \propto x^{0.80}}$$

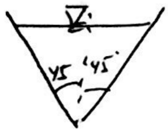
Q-6 (b)

$$Q = \underbrace{\frac{1}{n} A R^{2/3}}_{K} S^{1/2}$$

$$K = \frac{1}{n} A R^{2/3}$$

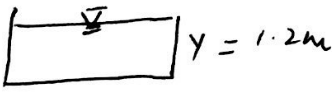
$$\boxed{K \propto \text{Area}}$$

Q-7 $\left(\frac{1}{2\sqrt{2}}\right)$ or 0.354
For most efficient triangular channel



$$R_e = \frac{y_e}{2\sqrt{2}}$$

$$\boxed{\frac{R_e}{y_e} = \frac{1}{2\sqrt{2}}} \quad \text{or} \quad \boxed{\frac{R_e}{y_e} = 0.354}$$



Q-8 (57.4) $n = 0.016$

$$C = \frac{1}{n} R^{1/6}$$

$$R_e = \frac{y_e}{2} = \frac{1.2}{2} = 0.6 \text{ m}$$

$$C = \frac{1}{0.016} \times (0.6)^{1/6} = \boxed{57.4}$$

Q-9 (0.0238) $C = \sqrt{\frac{8g}{f}}$

$$C^2 = \frac{8g}{f} \Rightarrow f = \frac{8g}{C^2} = \frac{8 \times 9.81}{57.4^2}$$

$$\boxed{f = 0.0238}$$

Q-10 (2 cm) $\frac{\delta}{x} = \frac{5}{\sqrt{Re_x}} \Rightarrow \delta \propto x^{1/2}$

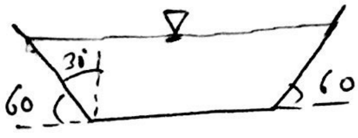
$$\frac{\delta_A}{\delta_B} = \sqrt{\frac{x_A}{x_B}} = \sqrt{\frac{x}{4x}} = \frac{1}{2}$$

$$\frac{1}{\delta_B} = \frac{1}{2} \Rightarrow \boxed{\delta_B = 2 \text{ cm}}$$

Q-11 (c)

$$[n] = [L^{-1/3}\,T]$$

Q-12 (b) (30°)



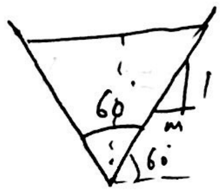
θ from vertical $= 30°$

Q-13 (c)

$$n = \frac{d_{50}^{1/6}}{24} = \frac{(2\times10^{-3})^{1/6}}{24}$$

$$= 0.014$$

Q-14 (d)



$\tan 60 = \frac{1}{m}$

$m = \frac{1}{\tan 60}$

$m = 0.577$

$$y_c = \left(\frac{2Q^2}{g m^2}\right)^{1/5}$$

$$y_c^5 = \frac{2Q^2}{g m^2} \Rightarrow Q^2 = \frac{y_c^5 \cdot g m^2}{2}$$

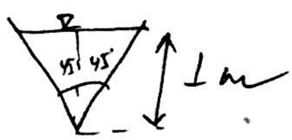
$$Q = \sqrt{\frac{y_c^5 \cdot g m^2}{2}} = \sqrt{\frac{(0.25)^5 \times 9.81 \times 0.577^2}{2}}$$

$$Q = 0.0399\ m^3/s$$

$$Q = 0.0399 = \boxed{40\ l/s}$$

Q-15 (0.695 N/m²)

$\tau = \gamma_w R S$



$$R = \frac{y}{2\sqrt{2}} = 0.354$$

$$\tau = 9.81\times10^{3}\times0.354\times\frac{1}{5000} = \boxed{0.695\ \frac{N}{m^2}}$$

Q-16 (Turbulent) $\quad \frac{u}{U} = \underbrace{\left(\frac{y}{\delta}\right)^{1/7}}_{\text{Turbulent}}$

Q-17

$$\left.\frac{dv}{dy}\right|_{y=0} \quad \propto \quad P_{min}$$

Q-18 a

For shallow stream

$$V_{avg} = V_{0.6}$$

Q-19 (59.92)

$$V = 0.605\ m/s$$

$$\tau_w = \gamma_w R S$$

$$1 = 9.81\times10^{3}\times RS$$

$$RS = \left(\frac{1}{9.81\times10^{3}}\right)$$

A/c to Chezy Eqn, $\quad V = C\sqrt{RS}$

$$V^2 = C^2(RS)$$

$$C^2 = \frac{V^2}{RS}$$

$$C = \sqrt{\frac{V^2}{RS}} = \frac{V}{\sqrt{RS}}$$

$$C = \frac{0.605}{\sqrt{\frac{1}{9.81\times10^{3}}}}$$

$$\boxed{C = 59.92}$$

Q-20 (2.32×10^{-4} mm)

Laminar Sublayer (δ') $= \dfrac{11.6\nu}{U_*}$

$$U_* = \sqrt{\frac{\tau_0}{\rho}} = \sqrt{\frac{1\times10^3}{1000}} = 1$$

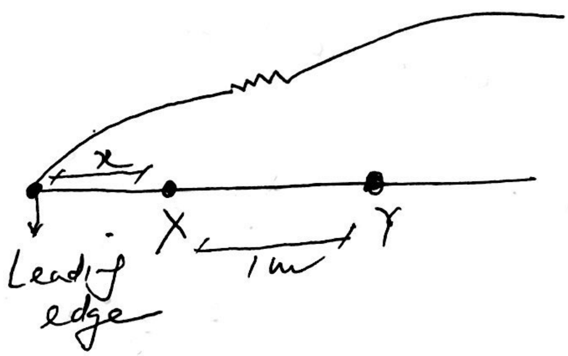
$$\nu = \frac{\mu}{\rho} = \frac{2\times10^{-4}\times0.1}{1000}$$

$$= 0.2\times10^{-7}\ m^2/s$$

$$\delta' = \frac{11.6 \times 0.2\times10^{-7}}{1} = 2.32\times10^{-7}\ m$$

$$(\delta' = 2.32\times10^{-4}\ mm)$$

Q-21 (0.8 m)



$$\frac{\delta}{x} = \frac{5}{\sqrt{Re_x}} \Rightarrow \delta \propto x^{1/2}$$

$$\frac{\delta_X}{\delta_Y} = \sqrt{\frac{x_X}{x_Y}}$$

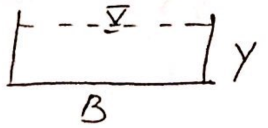
$$\frac{2}{3} = \sqrt{\frac{x}{x+1}} \Rightarrow \frac{4}{9} = \frac{x}{x+1}$$

$$4x + 4 = 9x$$

$$5x = 4$$

$$x = \frac{4}{5} = \boxed{0.8\ m}$$

Q-22 (36%)



For wide Rectangular channel

$$R \simeq y$$

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

$$Q = \frac{1}{n} \times By \times y^{2/3} S^{1/2}$$

$$Q \propto y^{5/3} \Rightarrow Q = K y^{5/3}$$

$$Q_1 = K_1 y_1^{5/3}$$

$$Q_2 = K_1 (1.2 y)^{5/3} = 1.36 K y^{5/3}$$

$$\% \text{ Increase} = \frac{0.36 K y^{5/3}}{K y^{5/3}} \times 100 = \boxed{36\%}$$

Q-24 (b)

$$\frac{u}{U} = \left(\frac{y}{\delta}\right)^{1/7}$$

$$\text{Displacement thickness } (\delta^*) = \int_0^\delta \left(1 - \frac{u}{U}\right) dy$$

$$= \int_0^\delta \left(1 - \left(\frac{y}{\delta}\right)^{1/7}\right) dy$$

$$= [y]_0^\delta - \frac{7}{8} \frac{1}{\delta^{1/7}} \cdot \left[y^{8/7}\right]_0^\delta$$

$$= \delta - \frac{7}{8 \cdot \delta^{1/7}} \cdot \delta^{8/7}$$

$$= \delta - \frac{7}{8} \cdot \delta^{\frac{8}{7} - \frac{1}{7}} = \delta - \frac{7}{8}\delta$$

$$\boxed{\delta^* = \frac{\delta}{8}}$$

$$\text{Momentum thickness } (\theta) = \int_0^\delta \frac{u}{U}\left(1 - \frac{u}{U}\right) dy$$

$$= \int_0^\delta \left(\frac{y}{\delta}\right)^{1/7} \left\{1 - \left(\frac{y}{\delta}\right)^{1/7}\right\} dy$$

$$= \int_0^\delta \left(\frac{y}{\delta}\right)^{1/7} dy - \int_0^\delta \left(\frac{y}{\delta}\right)^{2/7} dy$$

$$\theta = \frac{7}{8\,\delta^{1/7}}\left[y^{8/7}\right]_0^{\delta} - \frac{7}{9\cdot\delta^{2/7}}\left[y^{9/7}\right]_0^{\delta}$$

$$= \frac{7}{8\,\delta^{1/7}}\left[\delta^{8/7}\right] - \frac{7}{9\cdot\delta^{2/7}}\left[\delta^{9/7}\right]$$

$$= \frac{7}{8}\delta - \frac{7}{9}\delta = \left(\frac{63-56}{72}\right)\delta$$

$$\boxed{\theta = \frac{7}{72}\delta}$$

Shape factor (SF) $= \frac{\delta^*}{\theta} = \frac{\delta}{8} \times \frac{72}{7\delta} = \boxed{\frac{9}{7}}$

Q-23 (d)

$$\frac{u}{U} = \frac{y}{\delta}$$

$$\theta = \int_0^{\delta} \frac{u}{U}\left[1-\frac{u}{U}\right] dy$$

$$\theta = \int_0^{\delta} \frac{y}{\delta}\left(1-\frac{y}{\delta}\right) dy = \int_0^{\delta} \frac{y}{\delta}\,dy - \int_0^{\delta}\left(\frac{y}{\delta}\right)^2 dy$$

$$= \frac{1}{\delta}\left[\frac{y^2}{2}\right]_0^{\delta} - \frac{1}{\delta^2}\left[\frac{y^3}{3}\right]_0^{\delta}$$

$$= \frac{\delta}{2} - \frac{\delta}{3} = \boxed{\frac{\delta}{6}}$$

Q-25 (1.6)

$$\frac{\delta}{x} = \frac{5}{\sqrt{Re_x}}$$

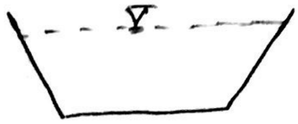
$$\frac{\delta_1}{\delta_2} = \sqrt{\frac{Re_2}{Re_1}} = \sqrt{\frac{256}{100}} = \frac{16}{10} = 1.6$$

$$\boxed{\frac{\delta_1}{\delta_2} = 1.6}$$

Q-2~~6~~ (d)

$$\frac{u}{U} = \sin\left(\frac{\pi}{2}\cdot\frac{y}{\delta}\right)$$

Q-27 (0.015)



$$Q = 21.5 \ m^3/s$$

$$S = \frac{1}{2500}$$

$$C = 70$$

A/c to chezy's Eqn

$$Q = AC\sqrt{RS}$$

$$21.5 = \sqrt{3}\, y_e^2 \times 70 \times \sqrt{\frac{y}{2} \times \frac{1}{2500}}$$

$$y_e = 2.75 \ m$$

$$R_e = \frac{y_e}{2} = 1.375 \ m$$

$$C = \frac{1}{n} R^{1/6}$$

$$n = \frac{1}{C} R^{1/6} = \frac{1}{70} \times (1.375)^{1/6}$$

$$\boxed{n = 0.015}$$

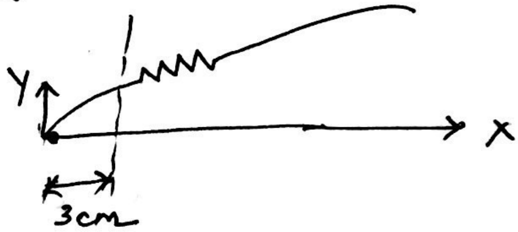
Q-28 (d)

$$C_D = \frac{1.328}{\sqrt{Re_L}} \quad , \quad C_D \propto Re_L^{-0.5}$$

Q-29

$$\boxed{F_r = \frac{\sqrt{2}\, V}{\sqrt{g y}}}$$

Q-30. (a)



$$\frac{\delta}{x} = \frac{5}{\sqrt{Re_x}}$$

$$\delta = \frac{5.x}{\sqrt{Re_x}} = \frac{5 \times 30}{\sqrt{1 \times 10^5}} = \frac{15\cancel{0}}{10\cancel{0}\sqrt{10}}$$

$$\boxed{\delta = 0.47 \ mm}$$