University of Asia Pacific

Department of Civil Engineering

Final Examination Fall 2012

Program: B.Sc. Engineering (Civil)

Course title: Open Channel Flow Course code: CE 361

Time: 3 hours Total Marks: 100

Answer any **FIVE** out of **SEVEN** questions. Each question has **20** marks. The figures in the right margin indicate full marks.

1.

a) Define the following terms: 6

a. Manning's coefficient b. Normal depth c. Chezy's C

b) State the characteristics of uniform flow in an open channel. 3

c) Water flows at a velocity of 1 m/s in an open channel under uniform flow condition. The longitudinal slope of the channel is 0.0016 and n=0.02. Compute the normal depth of flow when the channel is trapezoidal with b= 6 m and s=2. 5

d) A rectangular channel has a bottom width of 5 m and Manning's coefficient n=0.025. The channel lies on a slope of 1 in 1000. Determine the critical slope when discharge is 20 m^3/s. 6

2.

a) An open channel with concrete lining (d_{50}= 1.5mm) is laid on a slope of 0.1%. The channel is trapezoidal with bottom width of 3.5m and side slope s=2. If the depth of flow is 2.1m, find the uniform flow Q, Chezy's coefficient 'C' and friction factor 'f'. 6

b) Differentiate between 'section factor' and 'conveyance' for uniform flow in an open channel. 4

c) An unlined irrigation channel (n=0.025) is trapezoidal and has a bottom width of 7m, side slopes of 1:1, and depth of flow of 2m. The longitudinal slope of the canal is 0.0005. It is proposed to line the canal with concrete (n=0.013). Compute the discharge when only sides are lined with concrete. 6

d) List the factors that affect the Manning's coefficient 'n'. 4

3.

a) What is a lined channel? What are the reasons for lining a channel? 5

b) A lined channel (n=0.015) is to be laid on a slope of 1 in 2500. The side slope of the channel is to be maintained at 1.5:1. Determine the dimensions of a trapezoidal section with rounded corners to carry a discharge of m^3/s when the maximum permissible velocity is 2 m/s. 7

c) Define a best hydraulic section. Why do you think it is not always possible to find a best hydraulic section? 4

d) Show that the best hydraulic triangular section is one half of a square. 4

4.

a) Define the following terms: 6

   a. Maximum permissible velocity
   b. Non-silting velocity
   c. Freeboard

b) A trapezoidal channel is to be laid on a slope of 1 in 1000 and carry a discharge of 20 m^3/s. It is to be excavated in earth containing slightly rounded coarse non-cohesive particles with d_{75}= 3 cm and n= 0.025. Determine the section dimensions of the channel using the method by Lane. 6

c) What is 'angle of repose'? Why critical shear stress is important for channel design? 4

d) A horizontal trapezoidal channel having bottom width b= 5.5m, s=2 carries a discharge of 130 m^3/s at a depth of 1.1 m. Compute the downstream depth that will form a hydraulic jump. Find the energy loss in the hydraulic jump. 4

5.

a) Write down the characteristics of 'Gradually Varied flow". 4

b) Derive the following equation for gradually varied flow in an open prismatic channel. State the assumptions you made to derive the equation. 6

$$dy/dx = (S_o - S_f)/(1 - Fr^2)$$

c) In terms of the above equation, how do you explain 'backwater curve' and "drawdown curve"? 3

d) A rectangular channel with b= 4 m, and n=0.015 carries a discharge of 18 m^3/s. Identify the flow profiles produced in the channel for the following changes in the channel bottom slope:

S_o= 0.004 to S_o=0.009 7

6.

a) Sketch the possible water surface profiles in the following cases: 6

   a. Horizontal slope – Mild slope --- Critical slope

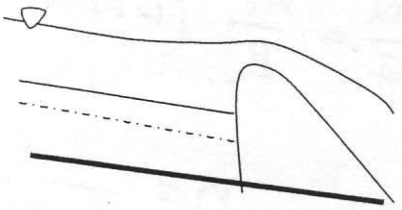
   b. Steep slope --- Critical slope ---Mild slope

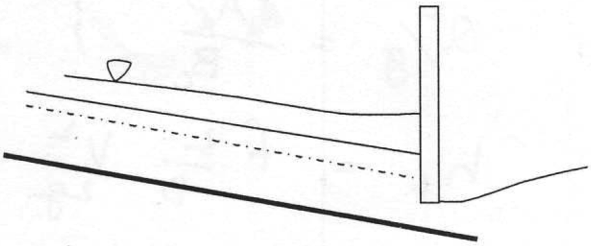
   c. Mild slope --- Milder slope – Steep slope

b) A trapezoidal channel having $b=5m$, $s=2$, $n=0.02$ and $S_o=0.002$ carries a discharge of $48.67\ m^3/s$. A dam constructed across the channel raises the water level to a depth of 5 m immediately upstream of it. How far upstream or downstream from the dam will the depth be 4.75m? Use the direct step method. 6

c) Define 'tailwater depth'. Using sketches, describe the importance of 'tailwater depth' in hydraulic jump with respect to downstream water depth y_2. 5

d) What do you understand by 'control section'? Indicate control sections in the following figures. 3





7.

a) When does a hydraulic jump take place in an open channel? Write down some of the practical applications of a hydraulic jump. 4

b) The depth and velocity at the foot of an overflow spillway are 0.5m and 15.50m/s respectively. What tailwater depth is needed to form a hydraulic jump? If a jump is formed, determine the type of jump, the height of jump, the length of jump, and the energy loss in the jump as a percentage of the initial energy. 6

c) A rectangular channel is 1.5 m wide, and inclined at an angle of 4.0 degree with the horizontal. The channel carries a discharge of $0.75\ m^3/s$ at a vertical depth (h_1) of 0.05 m. If a hydraulic jump occurs in this channel, compute the sequent depth, length of jump and height of jump. 6

d) State the differences between steady jump, weak jump and strong jump. 4

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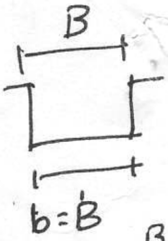
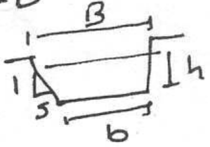
FORMULAE

1. $A = bh$; $P = b + 2h$; $B = b$



2. $A = (b+sh)h$; $P = b + 2\sqrt{1+s^2}\,h$

$B = b + 2sh$;

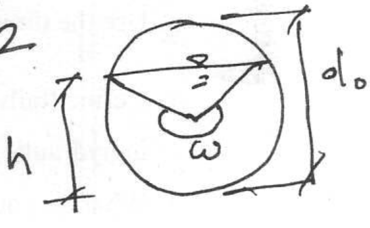


3. $A = sh^2$; $P = \left(2\sqrt{1+s^2}\right) * h$; $B = 2sh$

4. $h = d_0\left[1 - \cos\left(\frac{\omega}{2}\right)\right]/2$

$A = (\omega - \sin\omega)\, d_0^2/8$

$P = \omega d_0/2$



5. $Q^2/g = \dfrac{A_c^3}{B_c}$; $\dfrac{\alpha Q}{g} = \dfrac{A_c^3}{B_c}$ (when $\alpha \neq 1.0$)

6. $h_f = f\dfrac{L}{D}\dfrac{V^2}{2g}$; $n = \dfrac{d_{50}^{1/6}}{21.1}$

(d in meters)

7. $Re = \dfrac{VD}{\nu}$

8. $C = \sqrt{8g/f}$

9. $C = \dfrac{1}{n}R^{1/6}$

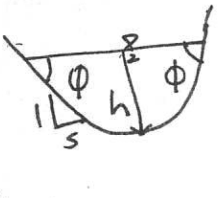
10. $\tau_0 = \gamma R S_0$

11. $u_* = \sqrt{\dfrac{\tau_0}{\rho}} = \sqrt{gRS_0}$

12. $\delta_v = \dfrac{11.6\,\nu}{u_*}$

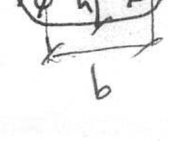
13. $A = h^2(\phi + \cot\phi)$

$P = 2h(\phi + \cot\phi)$



14. $A = bh + h^2(\phi + \cot\phi)$

$P = b + 2h(\phi + \cot\phi)$



15. Best hydraulic Sections

	A	P	B	D
Rectangle	$2h^2$	$4h$	$2h$	h
Triangle	h^2	$2\sqrt{2}h$	$2h$	$h/2$
Trapezoid	$\sqrt{3}h^2$	$2\sqrt{3}h$	$4\sqrt{3}h/3$	$3h/4$
Circle	$\pi h^2/2$	πh	$2h$	$\pi h/4$

16. For a trapezoidal best hydraulic section :

$$A = \left(2\sqrt{1+s^2} - s\right)h^2$$

$$b = 2\left(\sqrt{1+s^2} - s\right)h$$

$$P = 2h\left(\left(\sqrt{1+s^2}\right)*2 - s\right)$$

17. Erodible channel :

$\Rightarrow \tau_0 = \gamma R S_0.$

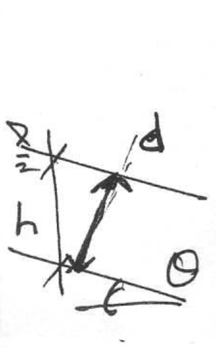
$\Rightarrow K = \frac{\tau_s}{\tau_b} = \sqrt{1 - \frac{\sin^2\phi}{\sin^2\varphi}}$

where
φ = angle of repose
ϕ = side slope angle.

$\Rightarrow$ permissible shear stress $= 0.4\,d_{75}$ (d_{75} in inches)

$\Rightarrow \bar{S_f} = (S_{f_1} + S_{f_2})/2$

$\Rightarrow x_2 = x_1 + \frac{E_2 - E_1}{S_0 - \bar{S_f}}$



18. $\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8G^2} - 1\right)$

19. $G^2 = K_1^2\,Fr_1^2$ where $K_1 = 10^{0.027\theta}$ (θ is in deg)

20. $h = d\cos\theta$

21. $$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8Fr_1^2} - 1\right)$$

or, $$\frac{y_1}{y_2} = \frac{1}{2}\left(\sqrt{1+8Fr_2^2} - 1\right)$$

Horizontal rectangular channel

22. $$h_L = \frac{(y_2-y_1)^3}{4y_1y_2}$$

23. $$\frac{L_j'}{y_1} = 9.75\,(Fr_1-1)^{1.01}$$

24. $$\frac{E_2}{E_1} = \frac{(1+8Fr_1^2)^{3/2} - 4Fr_1^2+1}{8Fr_1^2\,(2+Fr_1^2)}$$

25. $$\frac{h_3\ (\text{submerged})}{h_t\ (\text{tailwater})} = \left[1+2Fr_1^2\left(1-\frac{h_t}{h_g}\right)\right]^{1/2}$$

26. $$Fr^2 = \frac{Q^2B}{gA^3}$$

$Fr = 1$ (critical flow cond^n)

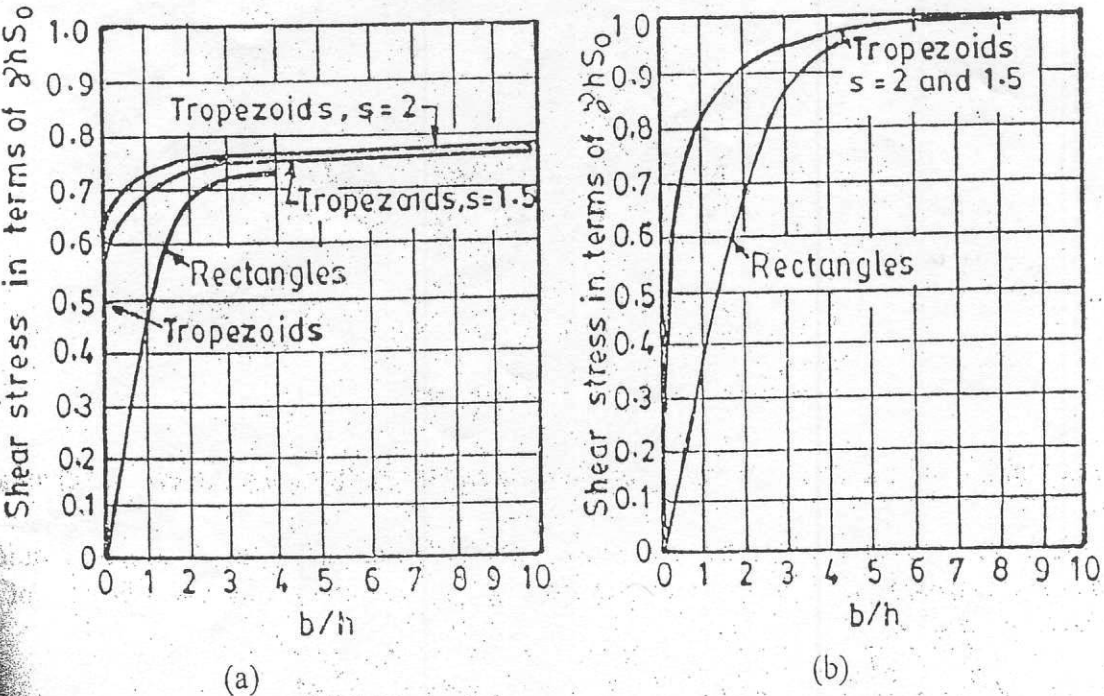
27. <u>$\bar{Z}$ for different sections</u>

Rectangle — $h/2$

triangle — $h/3$

trapezoid — $\frac{h}{6}\left(\frac{3b+2sh}{b+sh}\right)$

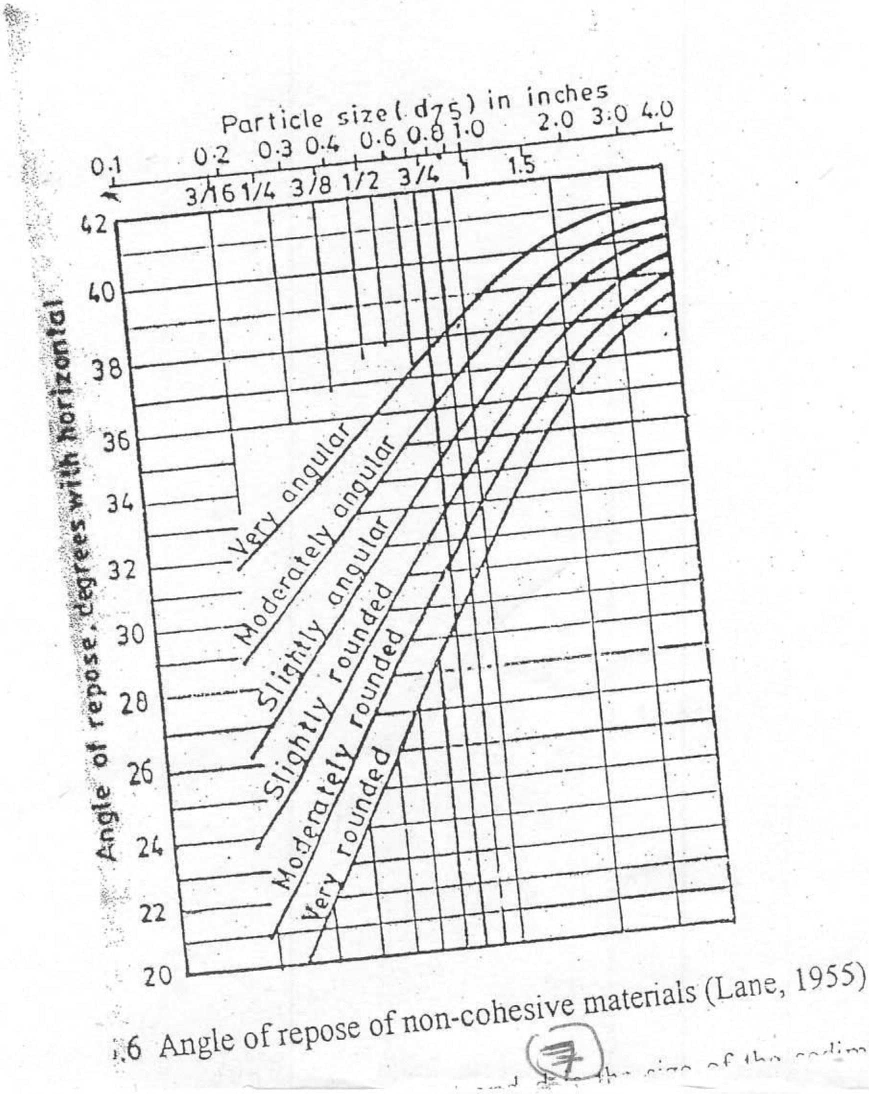
28. Specific force $F = \frac{Q^2}{gA} + \bar{Z}A$



(a) (b)

Fig. 5. 4 Maximum shear stresses on (a) sides and (b) bottom of trapezoidal channels

Stress Ratio



.6 Angle of repose of non-cohesive materials (Lane, 1955)

the size of the sediment particle. The