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ESE- 2018 (Prelims) - Offline Test Series Test-15

CIVIL ENGINEERING

SUBJECT: FLUID MECHANICS AND OPEN CHANNEL FLOW, HYDROLIC MACHINCHES AND HYDRO POWER + HYDROLOGY AND WATER RESOURCES ENGG + SURVEYING AND GEOLOGY
SOLUTIONS

01. Ans: (d)

Sol: $\mu = 9.81$ poise $= 9.81 \times 0.1 = 0.981$ pa.sec

dy = 1 cm = 10^{-2} m

du = 2 m/s

$$\tau = \mu \frac{du}{dy} = 0.981 \times \frac{2}{10^{-2}} = 196.2\,N/m^2$$

02. Ans: (a)

Sol: $V = \sqrt{2gx\left(\frac{S_m}{S} - 1\right)}$

x = manometric deflection

$$1.2 = \sqrt{2 \times 9.81 \times x\left(\frac{1.4}{1} - 1\right)}$$

$$x = \frac{(1.2)^2}{2 \times 9.81 \times 0.4}$$

x = 0.1835 m = 183.5 mm

03. Ans: (c)

Sol: $3h\times\rho + 1.5h \times 2\rho + h\times 3\rho - H\times 3\rho = 0$

(by Bernoulli's Equation)

$$\therefore \frac{H}{h} = 3$$

04. Ans: (d)

Sol: The ballast lowers the position of the centre of gravity and elevate the position of centre of buoyancy.

05. Ans: (a)

Sol: $u = 2x$

$$\frac{-\partial\phi}{\partial x} = u$$

$$\frac{\partial\phi}{\partial x} = -2x$$

$$\phi = -x^2 + f(y)$$

$$\Rightarrow \frac{\partial \phi}{\partial y} = f'(y) \quad \rightarrow (1)$$

$$V = -2y$$

$$V = \frac{-\partial \phi}{\partial y} \Rightarrow -2y = \frac{-\partial \phi}{\partial y}$$

$$\frac{\partial \phi}{\partial y} = 2y \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

From (1) & (2)

$f'(y) = +2y$

$\Rightarrow f(y) = +y^2 + C$

$f(y) = y^2 + C$

$\therefore \quad \phi = y^2 - x^2 + C$

06. Ans: (a)

Sol: For incompressible flow

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

$$\therefore \frac{\partial}{\partial x}\left(3xy^2 + 2x + y^2\right) + \frac{\partial}{\partial y}\left(x^2 - 2y - y^3\right) = 0$$

$$3y^2 + 2 - 2 - 3y^2 = 0$$

$$0 = 0$$

$\therefore$ There is no time component in the given expression; so it is steady

07. Ans: (b)

Sol: Euler's equation of motion are applicable to incompressible non viscous fluids in steady (or) unsteady state of flow.

08. Ans: (d)

Sol: $h_f = \dfrac{fLV^2}{2gd} = \dfrac{fLQ^2}{12.1d^5}$

$$Q^2 \propto \frac{1}{f}$$

$$\left(\frac{Q_2}{Q_1}\right)^2 = \frac{f_1}{f_2} = \frac{1}{1.25}$$

$$\left(\frac{Q_2}{Q_1}\right) = \sqrt{\frac{4}{5}} = \frac{2}{\sqrt{5}} = 0.89$$

It is decreased by 11%.

NOTE:-if error is large, this method is used for better results.

09. Ans: (d)

Sol: As per continuity equation

$$A_1V_1 = A_2V_2 + A_3V_3$$

$$D_1^2V_1 = D_2^2V_2 + D_3^2V_3$$

$$\left(\frac{D_1}{D_3}\right)^2 V_1 - \left(\frac{D_2}{D_3}\right)^2 V_2 = V_3$$

$$\left(\frac{450}{200}\right)^2 \times 3 - \left(\frac{300}{200}\right)^2 \times 2.5 = V_3$$

$\Rightarrow V_3 = 9.5625$ m/s

10. Ans: (c)

11. Ans: (c)

Sol: Using Hagen-Poiseuille's equation

$$\Delta P = \frac{32\mu VL}{D^2}$$

$$V = \frac{4Q}{\pi d^2} = \frac{4\times 0.01}{3.14\times 0.04} = \frac{1}{3.14}\ m/s$$

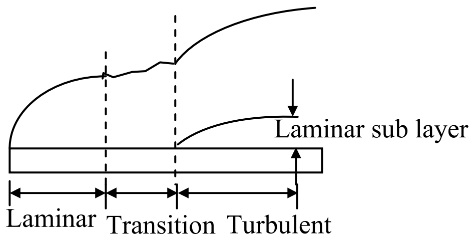
$$\Delta P = \frac{32\times 0.08\times 20\times 10^3\times 1}{3.14\times 0.04}\ Pa$$

Power required = Q. ΔP

$$= 0.01\times\frac{32\times 0.08\times 20\times 10^3}{3.14\times 0.04}\ Nm/s = 4.0764\ kW$$

12. Ans: (a)

Sol:



13. Ans: (d)

Sol: Pressure drag > Friction drag ⇒ Surface of body does not coincide with stream lines that are passing through it i.e. Bluff body

If stream lines coincides with surface of body, then the body called stream lined body, in these bodies friction drag is more.

14. Ans: (b)

Sol: Total Number of constant = 4–3 = 1

$$\pi_1 = V^a.\rho^b.g^c.\sigma$$

$$M^oL^oT^o = (LT^{-1})^a.(ML^{-3})^b.(LT^{-2})^c.(MT^{-2})$$

$$M^oL^oT^o = L^{a-3b+c}.M^{b+1}T^{-2C-2}$$

$$\therefore\ b = -1,\ C = -1,\ a = -2$$

$$\pi_1 = \frac{\sigma}{\lambda^2 g\rho}$$

15. Ans: (b)

Sol: Discharge scale ratio $Q_r = L_r^{5/2}$

$$\frac{Q_m}{Q_p} = L_r^{5/2}$$

$$Q_m = L_r^{5/2}\times Q_p = \frac{1}{(16)^{5/2}}\times 2048 = 2cumec$$

16. Ans: (d)

Sol: $Q = \frac{2}{3}C_dL\times\sqrt{2g}\left[(H+h_a)^{3/2} - h_a^{3/2}\right]$

$$= \frac{2}{3}\times 100\times\sqrt{2\times 9.81}\left[(1.5+0.02)^{3/2} - 0.02^{3/2}\right]$$

$Q = 552.6\ m^3/s$

Note: Such type of lengthy questions please avoid in first attempt

In second attempt if the options are far more than 100 ≃ 150 go through.

(Hand calculations)

$$\sqrt{2\times 9.81} = 4.42$$

$$(1.52)^{3/2} = \left(\frac{150}{100}\right)^{3/2} = \left[\frac{(12\approx 13)^2}{10^2}\right]^{3/2}$$

$$= \frac{12^3}{10^3} = \frac{1728}{1000} = 1.7$$

$$\left(\frac{2}{100}\right)^{3/2} = \frac{2^{1.5}}{1000} = 0.003$$

$1.7 - 0.003 \simeq 1.7$ $\qquad \because 152 \cong 12^2$

$$= \frac{2}{3}\times 100\times 4.42\times 1.7$$

≃ 500 nearest option 552.5 m^3/s

17. Ans: (c) **18. Ans: (c)**

19. Ans: (a)

Sol: $F = \rho AV(V_1 - V_2)$

$\because \; V_2 = 0$

$= \rho AV^2$

$= 0.7\times10^3 \times 0.03\times10^2$

$F = 2100$ N

$F = 2.1$ kN

20. Ans: (b)

Sol: NPSH is defined as the head required to make the liquid to flow through the suction pipe to the impeller.

NPSH should always be positive to keep away the cavitation

21. Ans: (b)

Sol: $U_2 = \dfrac{\pi D_2 N}{60} = \dfrac{3.14\times0.1\times3000}{60} = 15.7\,\text{m/s}$

For radial vane tips

$V_{w_2} = U_2 = 15.7\ \text{m/s}$

Manometric efficiency $\eta_m = 0.8$

$$\eta_m = \frac{gH}{V_{w_2}u_2}$$

$$\frac{gH}{V_{w_2}u_2} = 0.8 \Rightarrow H = \frac{0.8\times(15.7)^2}{9.81} = 20.12\,\text{m}$$

22. Ans: (c)

Sol: At the exist of pelton turbine, no draft tube is employed. In reaction turbines draft tube is used.

Draft tube can't help to increase the available head in pelton turbine

23. Ans: (c)

Sol: Force per unit width

$$F = \frac{1}{2}\gamma_w \frac{(y_1 - y_2)^3}{y_1 + y_2}$$

$$F = \frac{1}{2} \times 9.81 \times \frac{(2.4)^3}{3.6}$$

$$F = 18.8 \text{ kN/m} \simeq 19 \text{ kN/m}$$

24. Ans: (b)

Sol: From the above flow net;

Size of the mesh is square;

$$q = \psi_1 - \psi_2$$

So,

$$16A_P V_p = 4V_R.A_R$$

$$16V_p = 4V_R$$

$$4V_p = V_R$$

Applying, Bernoulli's equation

$$P_p + \frac{\rho v_p^2}{2} + 0 = P_R + \frac{\rho v_R^2}{2}$$

$$(P_p - P_R) = -\frac{\rho v_p^2}{2} + \frac{\rho (4V_p)^2}{2}$$

$$(P_R - P_p) = -\frac{15\rho V_p^2}{2}$$

$$\left(\frac{\Delta P}{\frac{\rho v_p^2}{2}}\right) = -15$$

25. Ans: (a)

Sol: Evaporation rates tends to increase from colder region to warmer region. Colder region do not have high vapour pressure.

Hence, more pans are provided in arid regions. As per world meteorological organization (WMO) minimum density of evaporation pans is as follows.

Region	Density (km^2/station)
Arid region	30,000
Humid temperate	50,000
Cold region	1,09,000

26. Ans: (b)

Sol: $f_t = f_c + (f_o - f_c)\, e^{-kt}$

total infiltration

$$\int_o^8 f_t dt = f_c t + \frac{(f_o - f_c)}{-k}(e^{-kt})_o^8$$

$$= [f_c t]_o^8 + \frac{(f_o - f_c)}{(-k)}(e^{-8k} - 1)$$

$(k = 1; \quad e^{-8k}$ neglected$)$

$$= 8f_c + \frac{(f_o - f_c)}{k}$$

$$= (8 \times 1) + \frac{(5-1)}{1} = 12\,\text{cm}$$

i.e., infiltration in the pervious area

This occurs in the pervious area

$= 1000 - 400$

$= 600$ sqm

Average infiltration

$$= \frac{(600 \times 12) + (400 \times 0)}{100}$$

(Infiltration is the impervious region ~ o)

$= 7.2$ cm

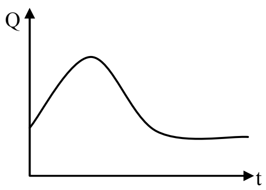
27. Ans: (a)

28. Ans: (d)

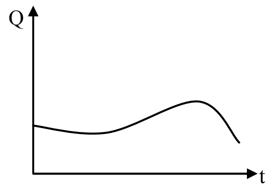
Sol: For estimation of severe floods, it is necessary to have information on maximum amount of rainfall for various duration occurring over various of catchment. Hence for a given duration D, maximum depth area curve is plotted for different storms and envelope curve of maximum D-A-D is obtained. Similarly envelope curves are drawn for different durations.

29. Ans: (d)

Sol: Shape of the flood hydrograph is affected by the axial distribution of rainfall. If the rainfall occurs only on the areas near outlet (say A_4) then it immediately got the peak (time of base is loss) and the hydrographs skews left



If the rainfall occurs in the regions for away from the outlet (say A_1) then peak is obtained after a long time (time d is more) and hydrograph skews right



30. Ans: (a)

Sol:

Area of DRH = total volume of runoff

= (area of catchment) × rainfall excess

$\Rightarrow\ 1.5 \times 10^6 = 25 \times 10^6 \times R$

$\Rightarrow\ R = 0.06$ m

$\Rightarrow\ R = 6$ cm

Total rainfall = 4 + 3.6 = 7.6 cm

Duration = 8 hr

$$\phi - \text{index} = \frac{7.6 - 6}{8} = 0.2 \text{ cm/hr}$$

31. Ans: (b)

Sol: Probability of occurrence of flow of magnitude ≥ 4000 m^3/sec

$$= \frac{1}{20} = 0.05 = P$$

Probability for flow < 4000 m^3/sec

$= 1 - 0.05 = q$

Life of structure = 50 years = r

Probability of occurrence of flow $\leq$ 4000 m^3/sec in entire life = event 'q' occurs in all 'n' years. i.e. event 'P' does not occur even once

$\Rightarrow\ nC_o(P)^\circ(q)^n$

$\Rightarrow\ (1-0.05)^{50}$

32. Ans: (b)

Sol: $S = K(\gamma I + (1-x)Q)$

Since prism storage depends on only outflow S = KQ wedge storage depends on both inflow and outflow $S_2 = KX(I-Q)$

$\therefore\quad S = S_1 + S_2$

'K' is slope of storage – discharge curve.

It is called as storage time constant and has units of time. It is the time of travel of flood wave through channel reach.

33. Ans: (c) **34. Ans: (c)**

35. Ans: (b)

Sol: Wind setup = $\dfrac{V^2F}{62000D}$

(Ref. IS 6512 to 1984)

$$= \frac{(175)^2\times 11}{62000\times 18} = 0.3\text{ m}$$

36. Ans: (b)

37. Ans: (b)

Sol: $$f_{loose} = \frac{4.75\times\sqrt{Q}}{5}$$

$$= \frac{47.5}{5} = 9.5\,\text{m}$$

38. Ans: (d) **39. Ans: (b)**

40. Ans: (c)

Sol: At toe maximum vertical stress

$$f_{yd} = \frac{\sum V}{b}\left(1+\frac{6e}{b}\right) = \frac{420}{140}\left(1+\frac{6\times 14}{140}\right) = 4.8\,\text{MPa}$$

Shear stress at toe, $\tau_d = f_{yd}\tan\phi_d$

$= 4.8\times 0.5$

$= 2.4$ MPa

41. Ans: (b)

Sol: Intensity of irrigation for kharif season

$I_k = 100 - 40 = 60$

Intensity of irrigation for Rabi season

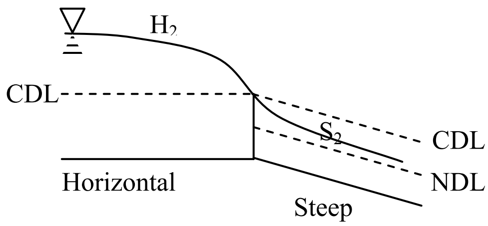
$I_r = 100 - 55 = 45$

Crop ratio $C_r = \dfrac{I_r}{I_k} = \dfrac{45}{60} = 0.75$

42. Ans: (b)

43. Ans: (b)

Sol:



If more than one slope along a channel is present, profiles of first slope are influenced by 2nd slope, 2nd slope are influenced by 3rd slope and so on.

In the present case, horizontal slope is followed by steep slope. Hence the steep slope having more downward slope, the horizontal profile will have falling profile. Therefore, 'H_2' is followed 'S_2'

[No other slope is shown in the diagram after steep slope]

Note: The 'S_2' profile shown is an example of hydraulic drop.

44. Ans: (a)

Sol: For parabolic channel,

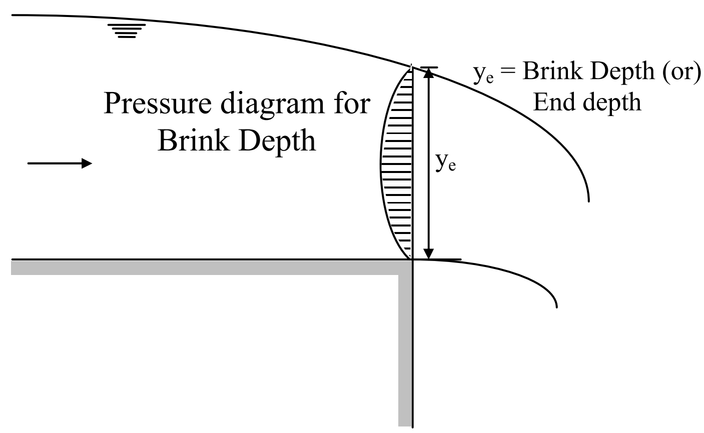
$$E_C = \frac{4}{3}y_c = \frac{4}{3}\times 3 = 4\,\text{m}$$

45. Ans: (c)

Sol: For critical depth, minimum specific energy and minimum specific force will be there. So, B is (3)

Conjugate depths (y_1, y_2): Occur in hydraulic jumps i.e., energy losses are complex. If energy losses are complex, instead of specific energy, momentum equation is used. For conjugate depths, (momentum equation) specific force diagram is used and conjugate depths have same specific force. So, A is (4)

Brink Depth (y_e):



46. Ans: (b)

Sol: A surge is unsteady rapidly varied flow. For surges we use continuity equation and momentum equation by converting into equivalent steady state.

47. Ans: (d)

Sol: For a throated flume modular limit will be high. '3' is wrong without '3' only option 'd'.

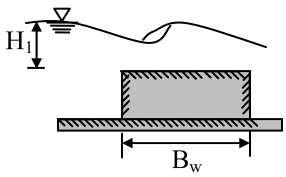
48. Ans: (b)

Sol:

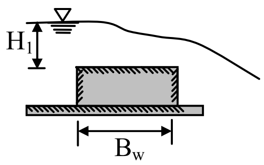
- The water surface profile of the free nappe will be a parabola.
- Velocity distribution of open channel flow is logarithmic.
- Specific energy curve is hyperbolic.

49. Ans: (b)

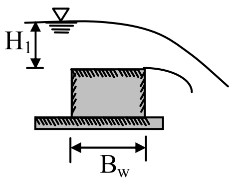
Sol:



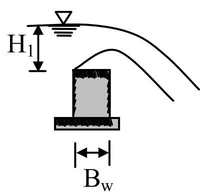
Long Crested Weir



Broad Crested Weir



Narrow Crested Weir



Sharp Crested Weir

50. Ans: (a)

Sol: $$\frac{1°}{3} = \frac{60'}{3} = 20'$$

$$L.C = \frac{20' \times 60''}{20'} = 60''$$

51. Ans: (a)

Sol: Shrunk scale = original scale × shrinkage factor

$$\text{Correct distance} = \frac{\text{measured distance}}{S.F}$$

$$\text{Correct distance} = \frac{9}{\left(\frac{\frac{1}{110}}{\frac{1}{100}}\right)} = 9.9 \text{ cm}$$

52. Ans: (c)

Sol: It is based on principle that lines on sheet parallel to their corresponding ground lines simultaneously.

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8 E&T DEEPALI GOYAL
9 E&T ABHISHEK PRATAP SINGH
10 E&T UMESH
8 IN TOP 10 RANKS
EE
2 EE PREETI KUMARI
3 EE
4 EE HARSHIT KUMAR SINGH
5 EE NIKHIL KUMAR
6 EE DUSHYANT SINGH
8 EE APOORVA GUPTA
9 EE KIRAN BABU KONERU
7 IN TOP 10 RANKS
ME
3 ME SAURABH
4 ME AMIT KUMAR RAI
6 ME ANKAN GUPTA
7 ME DHRUW JHA
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53. Ans: (a)

Sol:

Station point	Chainage	B.S	F.S	Rise	Fall	R.L
A	0	0.855				380.00
	30	0.585	3.455		2.6	
B	60		3.845		3.26	374.14

$$\text{Gradient} = \frac{380-374.14}{60}$$

$$= \frac{1}{10.23}$$

54. Ans: (d) **55. Ans: (a)**

56. Ans: (d)

Sol: Altimeter to measure altitudes.

57. Ans: (c)

Sol: Number of photographs in each strip is given by

$$N_1 = \frac{L_1}{(1-P_\ell)\frac{\ell}{S}} + 1$$

$$= \frac{10\times10^3}{(1-0.6)\times\frac{\frac{0.20}{10}}{100\times1000}} + 1 = 14$$

$$N_2 = \frac{w_1}{(1-P_w)\frac{w}{S}} + 1 = \frac{8\times10^3}{(1-0.3)\times\frac{\frac{20}{10}}{100\times1000}} + 1$$

$N = N_1 \times N_2 = 14 \times 7 = 98$

58. Ans: (a) **59. Ans: (c)**

60. Ans: (d)

Sol: Radius, R = 80 m

Length of long chord, L = 70 m

Length of mid ordinate,

$$O_m = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

$$= 80 - \sqrt{80^2 - \left(\frac{70}{2}\right)^2}$$

$= 8.06$ m

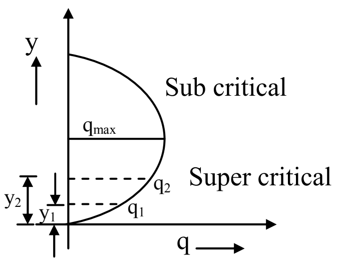
61. Ans: (c)

Sol: After certain limit, yield decreases with further increase in quantity of water applied.

62. Ans: (c)

63. Ans: (c)

Sol: For, $F_r > 1$, Super critical flow will occur



From above discharge curve $y_2 > y_1$, so depth will increase

'y' represents potential energy. As potential energy increases kinetic energy decreases

From the above relations Statement (I) is correct.

If channel is contracted discharge for unit width (q) will increase (i.e.) if $b_2 < b_1$ then ($q_2 > q_1$)

Statement (II) is wrong.

64. Ans: (b)

Sol: The celerity of disturbances in open channel flow, $C = \sqrt{g.D_H}$

D_H = hydraulic depth

Given, Critical flow occurs i.e., $F_r = 1$

$$F_r = \frac{V}{\sqrt{gy}} = 1$$

$$V = \sqrt{gy}$$

So, V = C

Statement (I) is true

For critical flow, $\frac{Q^2}{g} = \frac{A^3}{T}$

Critical depth is independent of longitudinal slope of channel.

So Statement II is true and it is independent from statement I.

So, answer (b)

65. Ans: (a)

66. Ans: (d)

Sol: When temperature is increased the reduction of cohesion in water molecules reduces viscosity. For air, the molecular momentum transfer increases and the viscosity also increases.

67. Ans: (a) **68. Ans: (b)** **69. Ans: (b)**

70. Ans: (a)

Sol: If sufficient moisture is always available to completely meet the needs of vegetation, then resulting evapotranspiration is potential evapotranspiration (PET).

The real evapotranspiration occurring in a specific situation in filed is actual evapotranspiration (AET).

Field capacity is the maximum quantity of water. That soil can retain against gravity.

So, when soil moisture is at field capacity, AET = PET

71. Ans: (a)

Sol: S-curve hydrograph is obtained by summation of infinite series of D hr unit hydrograph spaced D-h apart

∴ Average intensity = 1/D cm/hr

72. Ans: (a)

Sol: In Hydraulic routing, equation of unsteady flow along with equation of continuity used.

73. Ans: (b)

Sol: Unit hydrograph technique cannot be used in semi arid regions, as it requires constancy of hydrologic factors over a river basin

In Iso-Percentral method, lesser number of stations can be used to develop a quite detailed Isohyetal map. This method also avoids errors caused by imperfect distribution of rain gauges.

74. Ans: (a)

75. Ans: (c)

Sol: Silt change and silt grade is measured by using silt factor (f).