DETAILED SOLUTIONS

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MPSC 2019 : Main Exam
ASSISTANT ENGINEER

CIVIL ENGINEERING

Test 6

Subjectwise Test-6: Fluid Mechanics, Fluid Machines, Engineering Hydrology, Irrigation Engineering

ANSWER KEY

1.	(c)	11.	(a)	21.	(b)	31.	(c)	41.	(b)
2.	(b)	12.	(b)	22.	(d)	32.	(d)	42.	(a)
3.	(b)	13.	(c)	23.	(a)	33.	(a)	43.	(d)
4.	(b)	14.	(a)	24.	(a)	34.	(b)	44.	(b)
5.	(a)	15.	(b)	25.	(b)	35.	(c)	45.	(c)
6.	(b)	16.	(d)	26.	(c)	36.	(c)	46.	(c)
7.	(b)	17.	(b)	27.	(d)	37.	(c)	47.	(a)
8.	(c)	18.	(b)	28.	(a)	38.	(c)	48.	(a)
9.	(d)	19.	(c)	29.	(a)	39.	(d)	49.	(c)
10.	(c)	20.	(b)	30.	(a)	40.	(c)	50.	(d)

DETAILED EXPLANATIONS

1. (c)

Given, $u = \frac{3}{4}y - y^2$, $\mu = 0.84$ Ns/m^2

Shear stress:

$$\tau = \mu\frac{du}{dy} = \mu\left(\frac{3}{4} - 2y\right)$$

At $y = 30$ cm $= 0.3$ m

$$\tau = 0.84\left(\frac{3}{4} - 2\times0.3\right) = 0.126 \text{ N/m}^2$$

2. (b)

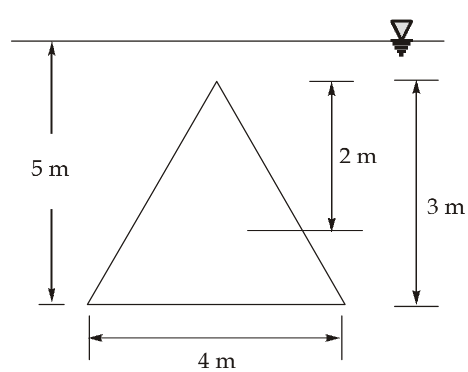
Newtonian fluid: Water, air, petrol, ethnol and benzene.
Pseudoplastic fluid: Gelatine, milk and blood.
Thixotropic fluid: Printer's ink, ketchup, certain paints and enamels.
Bingham plastic (Ideal plastic):
Tooth paste, sewage sludge.
Rheopectic fluid: Gypsum paste, Lubricants.
Dilatant's fluid: Solution with suspended starch or sand, sugar in water.

3. (b)

$$\Delta p = \frac{2\sigma}{R} = \frac{2\times0.5}{\left(\frac{1.6}{2}\times10^{-3}\right)} = 1250 \text{ N/m}^2$$

4. (b)

5. (a)



$$\text{Force} = P_{CG} \times \text{Area}$$

$$= 4\gamma_w \times \frac{1}{2} \times 4 \times 3 = 4 \times 10 \times \frac{1}{2} \times 4 \times 3 = 240 \text{ kN}$$

6. **(b)**

For completely submerged body.

Type of equilibrium	Remarks
Stable	G should be below B
Unstable	G should be above B
Neutral	G, B coincides

7. **(b)**

$$\text{Pressure of air} = -13.6 \times 0.25 = -3.4 \text{ m of water}$$

$$P_A = P_{air} + 4 \times 0.8$$

$$= -3.4 + 3.2 = -0.2 \text{ m of water}$$

$$P_A = -0.2 \times 9.81 = -1.962 \text{ kN/m}^2$$

$$= -1.962 \text{ kPa}$$

8. **(c)**

In eulerian method, we take a finite volume called control volume through which fluid flows in and out.

- The flow variable at a particular location, at a particular time, is the value of variable for whichever fluid particle happens to occupy that location at that time,

$$p = p(x, y, z, t)$$

$\cdot A$
(x, y, z, t)

$$\vec{V} = \vec{V}(x, y, z, t)$$

$$\vec{a} = \vec{a}(x, y, z, t)$$

9. **(d)**

10. **(c)**

$$\phi = x^2 - y^2$$

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

$$v = -\frac{\partial \phi}{\partial y} = 2y$$

$$\vec{V} = u\hat{i} + v\hat{j} = -2x\hat{i} + 2y\hat{j}$$

At (1, 1)

$$\vec{V} = -2\hat{i} + 2\hat{j}$$

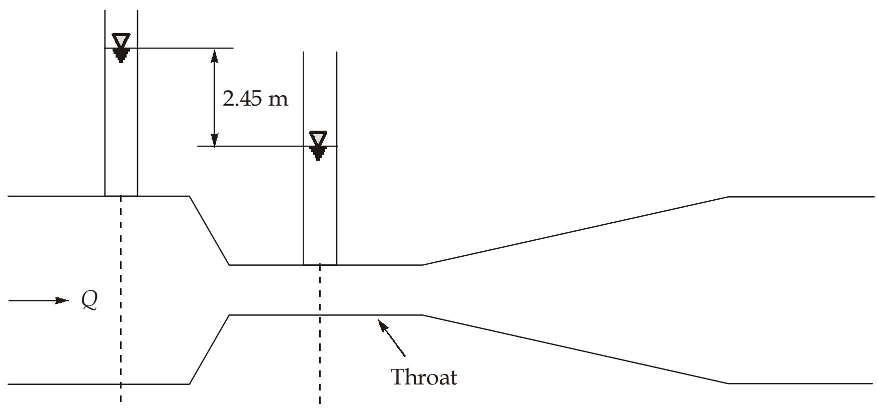
$$|\vec{V}| = \sqrt{(-2)^2 + (2)^2} = \sqrt{8} = 2\sqrt{2} \text{ units}$$

11. (a)

The condition to be satisfied for applicability of Bernoulli's equation are:

- Flow along a streamline.
- Flow is steady and incompressible.
- Effect of friction (viscous force) is neglisible, i.e. when fluid is ideal or when viscosity has neglisible effect.

12. (b)



Given,

$$d_1 = 15 \text{ cm}, h = 2.45 \text{ m}$$
$$d_2 = 7.5 \text{ cm}; g = 9.81 \text{ m/s}^2$$
$$Q = 30 \text{ lit/sec} = 30 \times 10^{-3} \text{ m}^3/\text{sec}$$

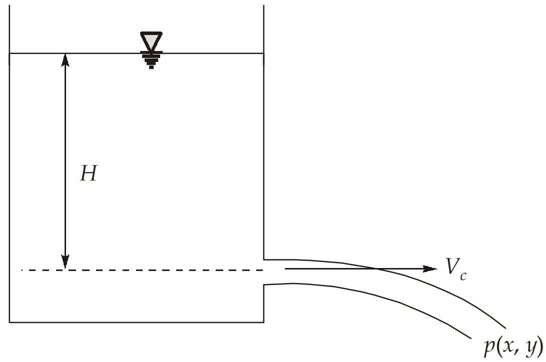
$$Q = C_d \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}$$

$$30 \times 10^{-3} = \frac{\frac{\pi}{4}(0.15)^2 \frac{\pi}{4}(0.075)^2}{\sqrt{\left(\frac{\pi}{4}\right)^2 \left((0.15)^4 - (0.075)^4\right)}} \sqrt{2 \times 9.81 \times 2.45}$$

$\Rightarrow$ $$C_d = 0.948 \simeq 0.95$$

13. (c)

14. (a)



$$x = V_c \times t$$

$$y = \frac{1}{2}gt^2 = \frac{1}{2}g\left(\frac{x}{V_c}\right)^2$$

$$V_c = \sqrt{\frac{gx^2}{2y}} \qquad \text{...(1)}$$

$$C_v = \frac{V_c}{\sqrt{2gH}} = \sqrt{\frac{gx^2}{2y \cdot 2gH}} = \sqrt{\frac{x^2}{4Hy}} = \frac{x}{2\sqrt{yH}}$$

15. (b)

For rectangular weir,

$$Q = \frac{2}{3}c_d\sqrt{2g}LH^{3/2}$$

$$Q \propto H^{3/2}$$

$$\Rightarrow \quad \frac{dQ}{Q} = \frac{3}{2}\left(\frac{dH}{H}\right)$$

$$\left(\frac{dQ}{Q}\right) = \frac{3}{2}\times(1.5) = 2.25\%$$

16. (d)

Critical depth for rectangular channel.

$$y_c = \left(\frac{q^2}{g}\right)^{1/3}$$

$$q = \frac{Q}{B} = \frac{15}{5} = 3 \text{ m}^3/\text{s/m}$$

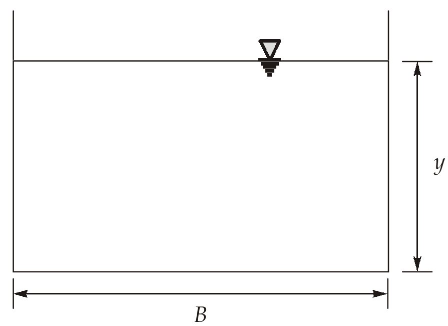
$$\Rightarrow \quad y_c = \left(\frac{9}{9.81}\right)^{1/3}$$

$$y_c = (0.92)^{1/3} \text{ m}$$

17. (b)

The expression $A\sqrt{D}\left(\text{where } D = \frac{A}{T}\right)$ is a function of the depth of flow 'y' for a given channel geometry and is known as section factor 'z'.

For a rectangular channel.

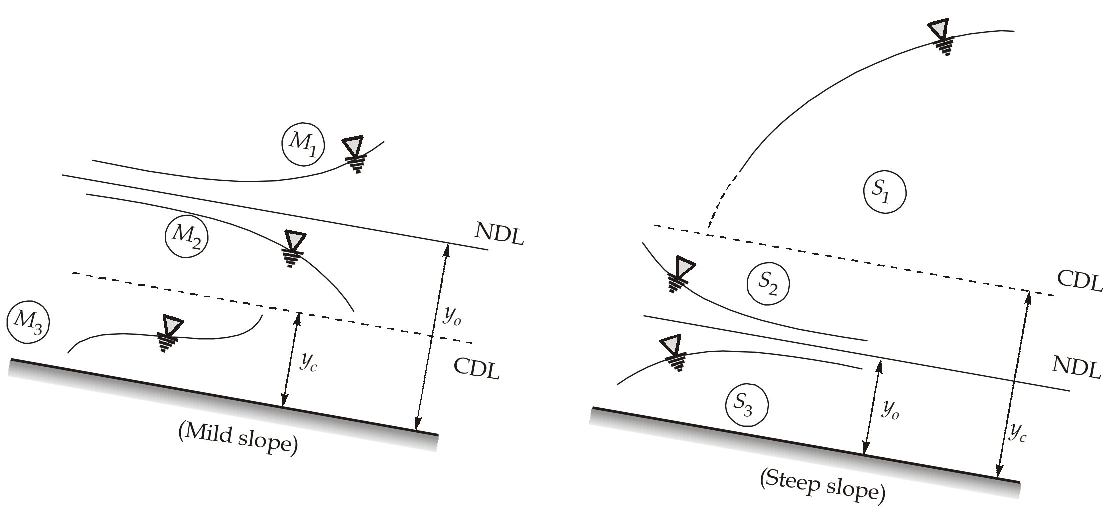


$$z = A\sqrt{\frac{A}{T}}$$

$$= (By)\sqrt{\frac{By}{B}} = By^{3/2}$$

$$z = By^{1.5}$$

18. (b)



19. (c)

As per Darcy Weisbach equation,

$$h_f = \frac{fLV^2}{2gD}$$

$$f = \text{friction factor}$$

For laminar flow,

$$h_f = \frac{32\mu VL}{\rho g D^2}$$

Hence, $$f = \frac{64}{\text{Re}}$$

Where, $$R_e = \frac{VD}{\nu}$$

20. (b)

In turbulent flow,

$$\frac{U_{max} - U_{avg}}{u_*} = 3.75 \text{ for both smooth and rough pipe.}$$

21. (b)

Due to decrease in velocity, the pressure gets increased in pipe and results in water hammer.

22. (d)

Momentum equation is not used in hardy cross method.

23. (a)

Loss of energy due to sudden enlargement $h_L = \dfrac{(V_1 - V_2)^2}{2g}$

Applying continuity equation $A_1V_1 = A_2V_2$

$$V_1 = V_2\left(\frac{A_2}{A_1}\right)$$

$\therefore$ $$h_L = \frac{V_1^2}{2g}\left(1 - \frac{V_2}{V_1}\right)^2$$

$$h_L = \frac{V_1^2}{2g}\left(1 - \frac{A_1}{A_2}\right)^2$$

24. (a)

(Von Kerman momentum integral equation)

$$\frac{\tau_o}{\rho U^2} = \frac{\partial\theta}{\partial x}$$

where,

$$\theta = \text{momentum thickness}$$
$$\tau_o = \text{boundary shear stress}$$
$$U = \text{free stream velocity}$$

25. (b)

Due to positive pressure gradient the boundary layer thickness increases rapidly which leads to the separation of stream lines early.

$$P_{\text{upstream}} < P_{\text{downstream}}$$

26. (c)

In distorted model where

$$L_{rH} \neq L_{rV}$$
$$V_r = \sqrt{L_{rV}}, \text{ (Since froude law is valid in river)}$$

and

$$A_r = L_{rH} \cdot L_{rV}$$
$$Q_r = A_r \cdot V_r$$
$$= L_{rH} \cdot L_{rV} \cdot (L_{rV})^{1/2}$$
$$Q_r = L_{rH}(L_{rV})^{3/2}$$

27. (d)

Specific speed: It is defined as the speed of a similar turbine working under a head of 1 m to produce a power output of 1 kW. The specific speed is useful to compare the performance of various types of turbines.

$$N_s = \frac{N\sqrt{P}}{H^{5/4}}$$

28. (a)

$$\eta_o = \eta_m \times \eta_h$$
$$0.7 = 0.85 \times \eta_h$$
$$\eta_h = \frac{0.7}{0.85} = 0.8235 = 82.35\% = 82\%$$

29. (a)

When two pumps are operating in series, then the pressure in the rising main will double while the discharge will remain nearly constant.

Whereas, if they are connected in parallel, head will remain same, but discharge become double

30. (a)

An air vessel is a closed chamber containing compressed air in the upper part and liquid being pumped in the lower part. The air vessels are used:

i. To get continuous supply of liquid at a uniform rate.
ii. To save the power required to drive the pump.
iii. To run the pump at a much higher speed without any danger of separation.

31. (c)
Hydrological cycle is the cycle in which water is transported from the occeans to the atmosphere as vapours, from the atmosphere to the land as precipitation and back from land to oceans as runoff.

32. (d)

33. (a)

- Evapotranspiration is the sum total of evaporation and transpiration. It is empirically determined by penman's method.
- Horton's equation

$$f_t = f_c + (f_o - f_c)\cdot e^{-k_h t}$$

f_t = Infiltration rate at any time t
f_o = Initial infiltration rate
f_c = Constant or equilibrium infiltration rate
k_h = Horton decay constant

- To generate synthetic unit hydrograph, synder's method is used.
- Muskingum method is a method of channel routing.

34. (b)
Probable maximum precipitation (PMP):
It is defined as the greatest or extreme rainfall of a given duration that is physically possible over a station or basin.

$$PMP = \overline{P} + k\sigma$$

$\overline{P}$ = mean annual rainfall series
k = frequency factor
σ = standard deviation of series

35. (c)

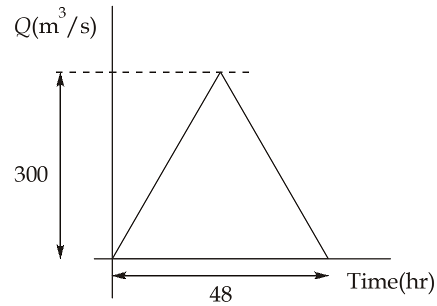
$$SR = \Sigma(i - \phi)\times t \qquad (i > \phi)$$
$$= (100 - 50) \times 1 + (80 - 50) \times 1 + (60 - 50) \times 1$$
$$= 50 + 30 + 10 = 90 \text{ mm}$$

36. (c)
Kirpich equation is an empirical equation used for the estimation of time of concentration.

37. (c)
Generally the climatic factors control the rising limb and the recession limb is independent of storm characteristics, it is determined by catchment characteristics only.

38. (c)

Area under UH gives direct runoff volume due to 1 cm effective rainfall over the catchment.



$$\frac{1}{2}\times(48)\times3600\times300 = (1\times10^{-2})\times \text{area}$$

$$\text{Area of catchment, } A = \frac{300\times48\times3600}{2\times10^{-2}} = 2592 \text{ km}^2$$

39. (d)

Sum of coefficients in muskingum equation is equal to 1.

40. (c)

The trap efficiency is defined as the percentage of the sediment deposited in the reservoir. Trap efficiency has been found to be a function of capacity inflow ratio.

$$\text{Trap efficiency } f\left(\frac{\text{Capacity of reservoir}}{\text{Total inflow of water}}\right)$$

41. (b)

$$x_T = \bar{x} + k\times\sigma_{n-1}$$

$$k = \frac{y_T - \bar{y}_n}{S_n}$$

x_T = Flood with a return period of T

$\bar{x}$ = mean value of flood

n = number of years of record

y_T = Reduced variate = $-\ln\cdot\ln\left(\frac{T}{T-1}\right)$

$\bar{y}_n$ = mean of reduced variate

S_n = Standard deviation of reduced variate

42. (a)

$$\text{Intrinsic permeability, } k_o = k\frac{\nu}{g}$$

$$= 1.96\times10^{-2}\times\frac{1\times10^{-6}}{9.81}$$

$$= 2\times10^{-9}\ \text{m}^2 = 2\times10^{-5}\ \text{cm}^2$$

$$1\ \text{darcy} = 9.87\times10^{-9}\ \text{cm}^2$$

$$k_o = \frac{2\times10^{-5}}{9.87\times10^{-9}} = 2026.34$$

43. (d)

In this type of irrigation, water does not actually wet the soil surface rather it flows underground and nourishes the plant root by capillarity.

44. (b)

$$D = \frac{\gamma_d}{\gamma_w}d(FC - PWP)$$

$$= \frac{1.5}{1}\times1000\times(0.3-0.1) = 300\ \text{mm}$$

45. (c)

If D is the duty of water on the field in hectares per cumec, Δ the total depth of water in metres supplied to a crop growing on the field during the entire base period and *B*, the base period of crop in days.

Then, from definitions of duty and delta we have

$$D\times\Delta\times10^4\ \text{m}^3 = 1\times B\times86400\ \text{m}^3$$

$$D = \frac{8.64B}{\Delta}$$

46. (c)

47. (a)

Gryones or spurs are constructed transverse to the river flow extending from the bank into the river. It's function is to train the river along the desired course.

48. (a)

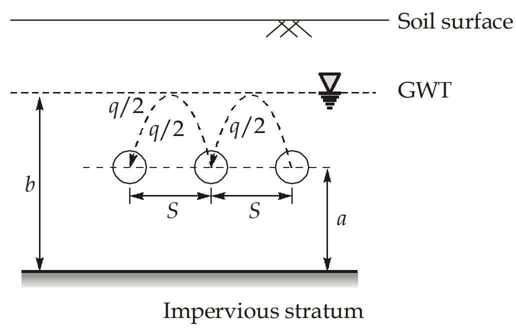
49. (c)

- Vertical acceleration downwards will reduce the effective weight of the dam. So it will decrease the overall stability of the dam.
- In reservoir full condition due to horizontal earth acceleration two forces generate (i) hydrodynamic pressure (by water on dam).

  (ii) Inertial force on dam

  When acceleration will occur horizontally U/S, both the forces act on the same side making it critical.

50. (d)



Spacing of tile drain, $S = \frac{4k}{q}(b^2 - a^2)$

$\Rightarrow$ $S \propto k$

k = coefficient of permeability of soil

q = discharge per unit length entering into the tile drain

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