समीक्षा

RSSB JE 2026

HYBRID TEST SERIES

SOLUTION

Paper ID
504

Stream
Civil Engineering (B.Tech)

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DETAILED EXPLANATIONS
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Exam Date
16 AUG 2026

Subject
FLUID MECHANICS & HYDRAULIC MACHINES & IRRIGATION & WATER RESOURCES

|| आपकी सफलता, हमारी प्रतिबद्धता ||

1. Answer B

Solution

SAR	Type of water
0 - 10	Low sodium
10 - 18	Medium sodium
18 - 26	High sodium
> 26	Very high sodium

Concentration of soluble salts (umho/cm)	Type of Irrigation water
0-250	C_1 (Low saline water)
250-750	C_2 (Moderate saline water)
750-2250	C_3 (High saline water)
> 2250	C_4 (Very high saline water)

2. Answer A

Solution

A = 1200 hect.

B = 140 days

Δ = 134 cm = 1.34 m

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

$$= 8.64 \times \frac{140}{1.34}$$

= 902.69 hect./cumec.

Dischrage required to irrigate 1200 hectare

B = 120 days

Δ = 52 cm = 0.52 m

$$D = 8.64 \times \frac{120}{0.52}$$

= 1993.85 hect./cumes.

So area that can be irrigated with discharge 1.329 cumec

= 1993.85 × 1.329 = 2650hect.

3. Answer C

Solution

Maximum velocity occurs at 0.81 times the diameter and maximum discharge occurs at 0.95 times the diameter.

4. Answer B

Solution

- **Canal drop:** It is an irrigation structure constructed across a canal to lower down its bed level to maintain the designed slope where change of ground level takes place.
- **Canal escape:** It is a side channel constructed to remove surplus water from an irrigation channel (main canal, branch canal or distributory etc.) into a natural drain.
- **Canal outlet:** It is a small structure built at the head of the water course so as to connect it with a minor or a distributory channel. It controls the discharge of water in water course.

5. Answer D

Solution

A lined alluvial canal is best designed on the basis of Manning's formula

6. Answer B

Solution

In normal shock waves the supersonic flow changes to subsonic flow. There is increase in pressure and density and a decrease in velocity. There is no change in momenturn per unit time. There is increase in entropy in the flow process, so temperature also increases.

7. Answer C

Solution

- **Drainage Density:-** Ratio of total channel length to the total drainage area.
- **Stream Density:-** Ratio of number of streams of all orders within basin to the catchment area.

8. Answer C

Solution

For S type profiles normal depth (y_0) is less than critical depth

$$y_0 < y_c \quad \text{or} \quad y_c > y_0$$

The actual depth of flow lies between NDL and CDL for S_2 profile.

$$y_c > y > y_0$$

9. Answer C

Solution

A. Isopleth	Line joining points of equal depth of Evapotranspiration
B. Isohyte	Line joining points of Equal rainfall magnitude
C. Isochrone	Line joining points of Equal time of concentration
D. Isopluvial	Line joining points of Equal depth of rainfall

10. Answer B

Solution

Supercritical flow is also called shooting flow.

11. Answer C

Solution

Total surface runoff

= (100 – 50) + (80 – 50) + (60 – 50)

= 50 + 30 + 10

= 90 mm

12. Answer C

Solution

$$q^2 = \frac{g y_1 y_2 (y_1 + y_2)}{2}$$

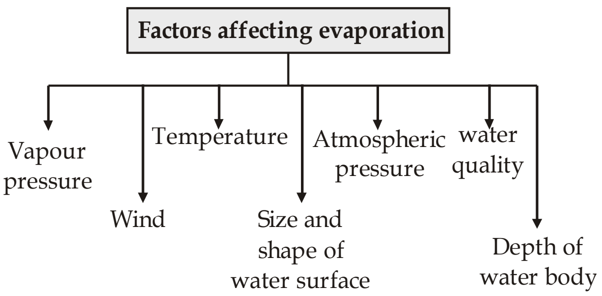
$$= \frac{9.81 \times 0.2 \times 1 \times 1.2}{2}$$

$$q = 1.08\, m^2/s/m$$

$$Q = 1.08 \times 4 = 4.32\, m^3/s$$

13. Answer C

- Salts dissolved in water reduces the evaporation because salt ions in the water reduces the free energy of water molecules.



14. Answer D

Solution

$$E = y + \frac{v^2}{2g}$$

$$V = \frac{Q}{by} = \frac{10}{2.5 \times 2} = 2\ m/s$$

$$E = 2 + \frac{2 \times 2}{2 \times 10} = 2.2m$$

15. Answer C

Solution

$$\frac{y_2}{y_1} = 8.0$$

$$y_1 = 0.5m$$

$$y_2 = 4m$$

$$E_L = \frac{(y_2 - y_1)^3}{4 y_1 y_2} = \frac{(3.5)^3}{4 \times 0.5 \times 4} = 5.4 Nm/N$$

16. Answer D

Solution

When intensity of rainfall is more than the infiltration capacity the rate of infiltration is equal to infiltration capacity.

The actual rate of infiltration f, at a given time can be expressed as:

$f = f_c$, when $i > f_c$

$f = i$, when $i < f_c$

Where, i is intensity of rainfall and f_c is the infiltration capacity at a given time; i, f and fc are expressed in cm/hr or mm/minute. The infiltration capacity (f_c) of a soil is high at the beginning of a storm and has an exponential decay as the time elapses.

17. Answer B

Solution

- Free overfall - Control section
- Standing wave flume - Hydraulic jump
- Surge - Celerity
- Weir - Clinging nappe

18. Answer C

Solution

Penman's equation is based on Energy budget method and mass transfer approach.

19. Answer C

Solution

Surge tanks are used to reduce water hammer effects. Water hammer occurs when a pipe is suddenly closed downstream, leading to high pressure building up because the mass of water before closure is still moving.

20. Answer C

Solution

Average depth of Rainfall over the catchment

$$=\frac{\Sigma P_i A_i}{\Sigma A_i}=\frac{6\times100+8\times200+10\times200}{100+200+200}=8.4\,\text{cm}$$

21. Answer B

Solution

If the sluice gate of the head race channel is suddenly closed (for closing turbine) positive surge will move upstream. If the sluice gate is suddenly opened (to start turbine) positive surge will move downstream.

22. Answer A

Solution

A flow duration curve is a plot of flow and percent of time that a particular discharge was equalled or exceeded. The area under the flow duration curve gives the average daily flow for a given period for which flow duration curve is plotted.

Application:

- To find out the maximum and minimum flow for a hydroelectric power plant.
- The shape of a flow-duration curve is used to evaluate the stream and catchment characteristics.
- A very steep curve means high flow for very short period of time and it would cause flood. On the other hand, flat curve means low flow region and it can sustain the flow.

23. Answer A

Solution

The head for pumping (H) = 4+16= 20 m

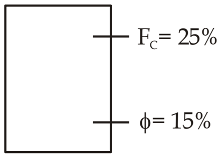
$$\text{Power required}=\frac{\rho g H Q}{\eta}$$

$$=\frac{9.81\times20\times0.025}{0.65}\text{kW}=7.5\,\text{kW}$$

24. Answer C

Solution

Root zone depth (D) = 80 cm



Depth of water stored b/w Field capacity (F_c) and Permanent wilting point (ϕ)

$$=\frac{\gamma_d}{\gamma_W}\times D\times(F_C-\phi)$$

$$=\frac{G}{\gamma_W}\times\gamma_W\times D\times(F_C-\phi)$$

= 1.5 × 80 × (0.25 – 0.15)

= 12 cm

25. Answer D

Solution

$$\text{Efficiency}=\frac{P_W}{P_S}$$

$$P_W=\frac{500\times250}{1000}=125\,\text{kW}$$

$$P_S=150\text{ kW}$$

$$\therefore\text{Efficiency}=\frac{125}{150}\times100\%=83.3\%\simeq82\%$$

26. Answer A

Solution

1. Wetted perimeter,

$$P=4.75\sqrt{Q}$$

$$P\propto\sqrt{Q}$$

Hence, P increase with increase in design discharge.

2. Hydraulic radius, $R=\frac{5}{2}\frac{V^2}{f}$

$$R\propto\frac{1}{f}$$

Hence, R decreases with increase in silt factor.

Also consider,

$$v=\left(\frac{Qf^2}{140}\right)^{1/6}$$

or $$v^6=\frac{Qf^2}{140}$$

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

27. Answer D

Solution

A **perfect fluid** (also known as an **ideal fluid**) is a **hypothetical/theoretical fluid** used to simplify fluid flow analysis. It is defined by **two key assumed properties:**

1. **Incompressible** — density remains **constant,** regardless of pressure changes
2. **Frictionless (inviscid) —** has **zero viscosity,** meaning it offers **no resistance to shear deformation**

28. Answer D

Solution

Given that :

Duration of storm = 6 hr.

Runoff = 4 cm/hr

$\therefore$ Total surface runoff = 4 × 6 = 24 cm

Hyetograph for the given intensity of rainfall.

Assume ϕ-index to be lower than 2 cm/hr

$$\therefore \quad \Sigma(i-\phi)\times t = \text{Surface runoff}$$

$$(2-\phi)\times 1+(6-\phi)\times 1+(8-\phi)\times 1+$$

$$(9-\phi)\times 1+(7-\phi)\times 1+(3-\phi)\times 1 = 24$$

$$35-6\phi = 24$$

$$6\phi = 35-24$$

$$\phi = 11/6 = 1.833\text{ cm / hr} < (2\text{ cm / hr})$$

Hence, $\phi = \text{index} = 1.833\text{ cm / hr}$

29. Answer C

Solution

Total force due to wave action on a gravity dam acts at a height of $\frac{3}{8}h_w$ above the reservoir surface

30. Answer C

Solution

Scour depth in alluvial rivers are calculated by following expression $R = 1.35\,(q^2/f)^{1/3}$

31. Answer B

Solution

- **To minimize seepage losses in canal** — Unlined earthen canals lose a vast amount of water due to percolation into the subsoil. Providing an impermeable concrete or masonry layer acts as a barrier, saving valuable water and preventing nearby fields from waterlogging.
- High water velocities generate immense hydraulic forces capable of scouring and wearing away earthen banks. A stable lining protects the structural profile of the canal against this erosion.
- **To decrease the discharge in the canal section by increasing the velocity** — Canal lining provides a smooth surface which reduces frictional resistance and *increases* velocity. However, according to the discharge equation (Q = AV), an increased velocity actually **increases the discharge capacity** of the canal section, rather than decreasing it

32. Answer B

Solution

Flow depth (y) = 3m

Critical Velocity (V_c) = $0.55\, y^{0.64}$

$= 0.55 \times (3)^{0.64} = 1.11$

33. Answer D

Solution

Assertion (A):

The behavior of viscosity with temperature is **opposite** for liquids and gases:

- **Water (liquid):** Kinematic viscosity **decreases** as temperature increases. This is because in liquids, viscosity arises mainly from intermolecular cohesive forces, which weaken as temperature rises, allowing molecules to move past each other more easily.
- **Air (gas):** Kinematic viscosity actually **increases** as temperature increases. In gases, viscosity arises from molecular momentum transfer (random molecular motion), which increases with temperature. Additionally, kinematic viscosity $\nu = \mu/\rho$ — for air, dynamic viscosity μ increases with temperature, and density ρ decreases with temperature (at constant pressure), so $\nu = \mu/\rho$ increases even more sharply with temperature.

Since the assertion claims **both** air and water show a decrease in kinematic viscosity with temperature, but air actually shows an increase, **A is FALSE.**

Reason (R):

This statement simply says kinematic viscosity (at a given pressure) is a function of temperature — which is **true** in general (it's the basis of viscosity-temperature charts/tables used in fluid mechanics), regardless of whether that function is increasing or decreasing. **R is TRUE.**

34. Answer C

Solution

It is best suitable for very light soil: Very light soils (such as sandy soils) possess high infiltration rates and low water-holding capacities. Traditional gravity or flood irrigation leads to severe deep percolation losses. The sprinkler irrigation method applies water evenly in controlled quantities like natural rain, which minimizes deep percolation losses and prevents nutrient leaching

35. Answer B

Solution

- An ideal fluid is assumed to have zero viscosity (μ = 0) meaning it offers no resistance to shear deformation whatsoever.
- Using Newton's Law of Viscosity:

$$\tau = \mu \frac{du}{dy}$$

- For an ideal fluid, since μ = 0:

$$\tau = 0 \times \frac{du}{dy} = 0 \text{ for all values of } \frac{du}{dy}$$

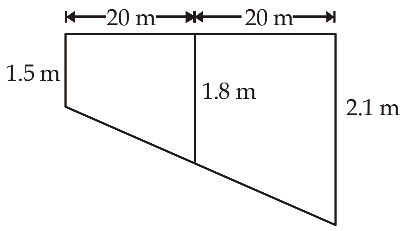
This means: no matter how large the shear rate (du/dy) becomes, the shear stress (τ) always remains zero.

On the τ vs. du/dy graph:

- Since τ = 0 for all values of du/dy (plotted on the X-axis), the graph is a horizontal line at τ = 0, which coincides with the positive X-axis itself.

36. Answer C

Solution



$$D_{avg} = \frac{2.1 + 1.7 + 1.5}{3} = 1.77$$

$$d_{avg} = \frac{0.3 + 0 + 0.3}{3} = 0.2$$

$$\eta_d = 1 - \frac{d}{D} = 1\,1 - \frac{0.2}{1.77} = 0.889$$

37. Answer: B

Solution

Let's analyze the given data:

du/dy (units)	0	1	2	4
τ (units)	10	15	20	30

Step 1: Check the behavior at du/dy = 0

At **du/dy = 0, τ = 10** (not zero!). This means the fluid requires a **minimum threshold shear stress (yield stress, τ_0 = 10)** before it starts to deform at all.

Step 2: Check the slope

From (0,10) to (1,15): slope = 5

From (1,15) to (2,20): slope = 5

From (2,20) to (4,30): slope = 5

The slope is constant = 5 — the relationship is **linear**, but with a **non-zero intercept.**

Step 3: Governing Equation

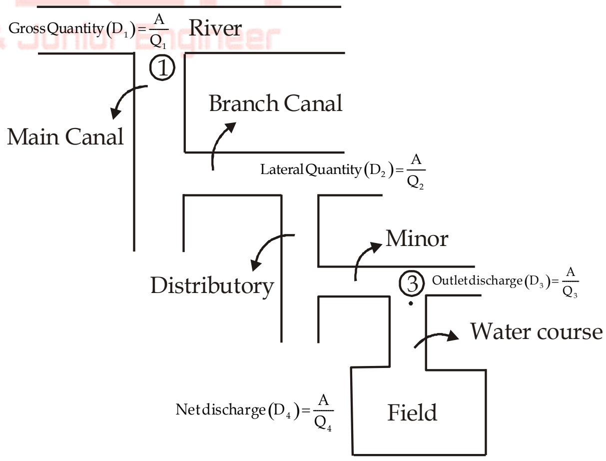
$$\tau = \tau_0 + \mu\left(\frac{du}{dy}\right) = 10 + 5\left(\frac{du}{dy}\right)$$

This is exactly the defining equation of a **Bingham Plastic fluid:**

$$\tau = \tau_0 + \mu\left(\frac{du}{dy}\right)$$

38. Answer B

Solution



39. Answer B

Solution

Given:

- D = 4 mm = 0.004 m
- Specific gravity = 0.6 → ρ = 600 kg/m³
- h = 20 mm = 0.02 m
- θ = 0°
- g = 9.81 m/s²

Formula for Capillary Rise

$$h = \frac{4\sigma \cos\theta}{\rho g d}$$

Solving for Surface Tension

$$\sigma = \frac{h \times \rho \times g \times d}{4\cos\theta} = \frac{0.02 \times 600 \times 9.81 \times 0.004}{4}$$

$$\sigma = \frac{0.47088}{4} = 0.1177\ N/m \approx 0.12\ N/m$$

Conclusion: The surface tension of the liquid is approximately **0.12 N/m,** matching option **(b)**.

40. Answer B

Solution

Parmanent welting point

$$= \frac{\text{Weight of water retained in the root zone corresponding to pwp}}{\text{Weight of dry soil}}$$

$$= \frac{\gamma_w (d \times A)}{\gamma_d (D \times A)}$$

$$= \frac{9.81 \times (0.4 \times 1)}{16 \times (1 \times 1)} \text{ Considering unit area}$$

PWP = 0.245

41. Answer C

Solution

Comparing each unit converted to Pascal (Pa):

1. **1 millibar**

   1 millibar = 100 Pa
2. **1 mm of mercury**

   1 mmHg = 13600 × 9.81 × 0.001 = 133.4 Pa
3. **1 cm of water**

   1 cm of water = 1000 × 9.81 × 0.01 = 98.1 Pa
4. **1 N/cm²**

   $$1 N/cm^2 = \frac{1}{10^{-4}} = 10{,}000 Pa$$

42. Answer C

Solution

It is a fall with raised crest and with vertical impact. The soils in Sarda command comprised sandystratum overlain by sandy-clay on which depth of cutting was to be kept minimum.

Design Characteristics of Sarda Fall are:

1. Discharge intensity varied from 1.6 to 3.5 cumec/s.
2. Drop varied from 0.6 to 2.5 m.
3. When the discharge of a canal is less than 14 cumecs, the section of the body wall is keptrectangular.
4. When the discharge of a canal is more than 14 cumec/s, the section of the body wall is kept trapezoidal with upstream batter 1: 3 and downstream batter 1: 8.
5. The depth of cut-off may range from 1 to 1.5 m.

43. Answer A

Solution

Assertion (A): TRUE

- An **ideal fluid** has **zero viscosity** (μ = 0), so it can **never** develop shear stresses — even when flowing. Since there's no shear stress anywhere, pressure at any point remains **isotropic** (equal in all directions).

Reason (R): TRUE

- **Pascal's Law** (pressure equal in all directions at a point) fundamentally holds whenever **shear stress = 0** — this applies to static fluids, ideal fluid flow, and rigid-body motion, not just static conditions alone.

Does R explain A?

- Ideal fluid → μ = 0 → shear stress = 0 everywhere (even while flowing)
- Pascal's law states pressure is equal in all directions whenever shear stress = 0
- Therefore, pressure must be equal in all directions in an ideal fluid flow

Conclusion: Both A and R are true, and R **correctly and directly explains** A, making the correct answer (a).

44. Answer C

Solution

As per rational formula, the peak value of discharge is expressed as

$Q_p = KAi$

$$= 0.5 \times 80 \times 10^4 \times \frac{3.6 \times 10^{-2}}{3600}$$

$= 4\ m^3/s$

45. Answer A

Solution

Tipping bucket type rain gauge consists of a circular collector funnel with a brass or gunmetal rim that directs the rain into a pair of tipping buckets. After rainwater has filled one side of the bucket with a small amount of rain, the assembly tips. An electrical pulse is generated on each tilt and is recorded toprovide data of rain fallen with time.

46. Answer D

Solution

- For a floating body, the **metacentric radius (BM)** — the distance from the center of buoyancy (B) to the metacenter (M) — is given by:

$$BM = \frac{I}{\forall}$$

Where:

I = moment of inertia of the waterline area about the longitudinal axis

∀ = volume of fluid displaced

Relating BM, BG, and GM

- Since B, G, and M all lie along the same vertical line (with G typically above B, and M above G for stable equilibrium):

$$BM = BG + GM$$

Substituting $BM = \frac{I}{\forall}$:

$$\frac{I}{\forall} = BG + GM$$

Rearranging (and noting GM = MG in magnitude):

$$BG + MG = \frac{I}{\forall}$$

47. Answer D

Solution

Specific retention of a rock or soil is the ratio of the volume of water a rock can retain against gravity to the total volume of the rock.

48. Answer B

Solution

Consumptive use of water

= 2 mm / day

Maximum depth of water in root zone

= 60 mm

Irrigation is required at 50% deficit

$$= \frac{50}{100} \times 60 = 30\text{mm}$$

Frequency of irrigation

$$= \frac{\text{Allowable deficit}}{\text{Consumptive use}} = \frac{30}{2}$$

= 15 days

49. Answer C

Solution

In linear reservoir storage varies linearly with out flow rate.

50. Answer C

Solution

- Steam-flow velocity is measured by current meter
- Evapo-transpiration is measured by Penman's method
- Infitration rate is calculated by Horton's method
- Wind velocity is measured by Anemometer

51. Answer D

Solution

Short reasoning:

- Stability rule: **M above G → stable; M below G → unstable**
- In the figure, order (top to bottom) is: **G → M → B, so M lies below G.**
- M below G ⟹ overturning moment ⟹ rotationally unstable

52. Answer C

Solution

Optimum number of rain gauges is given by

$$N = \left(\frac{C_v}{\varepsilon}\right)^2$$

$$C_v = \frac{\sigma_{n-1}}{P}$$

Where,

C_v is coefficieant of variation

ε is error percentage

Coefficient of variation is given by

$$C_v = \frac{\sigma_{n-1}}{P}$$

Where,

$\bar{P}$ is average rainfall

σ is standard deviation

53. Answer C

Solution

- The Continuity Equation is one of the most fundamental principles in fluid mechanics, based on the conservation of mass.

Statement of Continuity Equation

- For a fluid flowing through a stream tube (a bundle of streamlines forming a tube-like boundary, through which fluid enters and exits, but no fluid crosses the sides), the mass rate of flow (mass flow rate) must remain the same at every cross-section along the stream tube, assuming steady flow with no mass added or removed in between.

$$\dot{m} = \rho_1 A_1 V_1 = \rho_2 A_2 V_2 = \text{constant}$$

For incompressible flow (constant density):

$$A_1V_1 = A_2V_2 = Q(\text{constant})$$

This equation fundamentally relates the mass flow rate (or volumetric flow rate for incompressible fluids) at different sections along a stream tube, ensuring that mass is conserved as the flow moves through varying cross-sectional areas.

54. Answer A

Solution

If infiltration capacity of soil increases, maximum application rate by sprinklers decreases.

55. Answer C

Solution

Since stream function represents flow rate per unit width (in 2D flow), and discharge (Q) has dimensions:

$$[Q] = \frac{L^3}{T}(\text{volume flow rate})$$

For per unit width (dividing by a length, L, since 2D flow considers flow rate per unit depth/width):

$$[\psi] = \frac{[Q]}{[L]} = \frac{L^3T^{-1}}{L} = L^2T^{-1}$$

56. Answer C

Solution

T = kd

= (cm/ sec) × cm

= cm^2/sec

Dimenstion of ceefficient of transmissibility are $[M^0L^2T^{-1}]$

57. Answer A

Solution

(a) three-dimensional and unsteady

The velocity vector is $V = ax\,i + by^2\,j + czt^2\,k$

- Three-dimensional, since velocity components exist in all three directions (i, j, k) — $u = ax$, $v = by^2$, $w = czt^2$.
- Unsteady, since the w-component depends explicitly on time, t ($w = czt^2$), meaning $\partial w/\partial t \neq 0$ — the velocity at a fixed-point change with time.

58. Answer A

Solution

The resultant of the hydrostatic pressure and weight of the dam should pass through the outer third point.

$$B = \frac{H}{\sqrt{S-C}}$$

Considering zero uplift

$$H_{max} = B\sqrt{S} = 5\times\sqrt{2.25} = 7.5\text{m}$$

59. Answer A

Solution

The Hydraulic Grade Line (HGL) represents the sum of pressure head + elevation head at any point along a pipeline:

$$HGL = \frac{p}{\gamma} + z$$

The vertical distance between the HGL and the pipe centerline at any section directly represents the pressure head (p/γ) at that point.

Key Concept

- HGL above the pipe centerline → positive pressure head → p > atmospheric (positive gauge pressure)
- HGL below the pipe centerline → negative pressure head → p < atmospheric (negative gauge pressure, i.e., vacuum/suction condition)

Applying to Points A and B

At Point A: HGL is above the pipe centerline → positive pressure prevails at A (normal, above-atmospheric pressure)

At Point B: HGL is below the pipe centerline → this means the pressure head is negative at B → vacuum (sub-atmospheric) pressure prevails at B

HGL below pipe centerline at B → Vacuum pressure at B

60. Answer B

Solution

Given,

Return period, T = 40 years

n = 4 years

Probability of occurrence

$$P = \frac{1}{T} = \frac{1}{40} = 0.025$$

Probability of non-occurrence

q = 1 - P

= 1 - 0.025

q = 0.975

Probability of an event occurring At-least once in 4 successive years-

$p_{(n,1)} = 1 - q^n$

$p_{(4,1)} = 1 - (0.975)^4$

$p_{(4,1)} = 0.096$

61. Answer D

Solution

- The coefficient of discharge (C_d) is the product of the coefficient of contraction (C_c) and the coefficient of velocity (C_v):

$$C_d = C_c \times C_v$$

- Since C_v (coefficient of velocity) is always less than 1 — because actual velocity at the vena contracta is slightly less than theoretical velocity due to frictional resistance — multiplying C_c by this fraction ($C_v < 1$) makes:

$$C_d < C_c$$

- Typical values: $C_c \approx 0.62–0.65$, $C_v \approx 0.97–0.99$, giving $C_d \approx 0.61–0.65$, which is consistently less than C_c.

62. Answer B

Solution

Considered of unit hydrograph of triangular section

If the area of the catchment area is A.Km²

$$\frac{1}{2}\times 20\times(64\times 3600) = A\times\frac{1}{100}$$

A = 230.4 Km²

∵ Equilibrium discharge on S-curve

$$\boxed{Q_s = 2.778\times\frac{A}{D}}$$

$$\boxed{Q_s = 2.778\times\frac{230.4}{8}}$$

$$\boxed{Q_s = 80m^3/sec}$$

63. Answer B

Soution

- In a distorted river model, the horizontal scale (L_r) and vertical scale (h_r) are different, so we must treat area and velocity scaling separately based on the appropriate dimensions.
- Area ratio : The cross-sectional area of flow depends on one horizontal dimension (width) and one vertical dimension (depth):

$$A_r = L_r \times h_r$$

Velocity ratio:

- Velocity in open channel/river flow is governed by the Froude number, which depends on the vertical scale (depth), since gravity acts vertically and wave/flow behavior is controlled by depth:

$$V_r = \sqrt{h_r} = h_r^{1/2}$$

Discharge ratio:

$$Q_r = A_r \times V_r = (L_r \times h_r)\times h_r^{1/2} = L_r h_r^{3/2}$$

64. Answer. A

Solution

The lengths of the two dams are practically the, same but the volume of masonry in the gravity dam is three times that in the arch dam.

- In the case of a gravity dam the weight of the masonry is the principle element of resistance against the pressure of the water but in an arch dam the crushing strength of the stone and not its weight is the main force that resists the hydrostatic pressure.

Advantage of Arch dam-

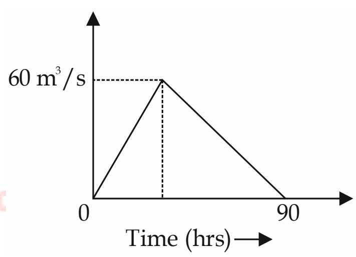
- Arch dams are particularly adapted to the gorged where the length is small in proportion to the height.
- For a given height the section of an arch dam is much lesser than a corresponding gravity dam.

65. Answer C

Solution

Area under DRH = Volume of direct runoff

$$\frac{1}{2}\times T_B \times Q_P = A\times E.R.D.$$



$$\frac{1}{2}\times 90\times 60\times 60s\times\frac{60m^3}{s} = 300\times 10^6 m^2\times E.R.D$$

Rainfall excess (E.R.D) $= 0.0324\,m = 3.24\,cm$

66. Answer B

Solution

Given:

Two identical pipes, each of length L, diameter D, friction factor f, connected in series

Total actual pipeline length = 2L (since two pipes of length L each are in series)

Equivalent single pipe has the same length L (not 2L) and same friction factor f — need to find its diameter, D_e

Using Dupuit's Equation for Equivalent Pipe

$$\frac{L_{eq}}{D_e^5} = \Sigma\frac{L_i}{D_i^5}$$

For the two pipes in series (each length L, diameter D):

$$\Sigma \frac{L_i}{D_i^5} = \frac{L}{D^5} + \frac{L}{D^5} = \frac{2L}{D^5}$$

Setting up the Equation

Since the equivalent pipe has length L (as specified in the question):

$$\frac{L}{D_e^5} = \frac{2L}{D^5}$$

Cancelling L:

$$\frac{1}{D_e^5} = \frac{2}{D^5}$$

$$D_r^5 = \frac{D^5}{2}$$

$$D_e = \frac{D}{2^{1/5}}$$

Calculating

$$2^{1/5} = 1.1487$$

$$D_e = \frac{D}{1.1487} = 0.8706\,D \approx 0.87\,D$$

Conclusion: The equivalent diameter is approximately 0.87 D, matching option (b).

67. Answer B

Solution

- Hydrologic flood routing uses the continuity equation
- Hydraulic flood routing uses both the continuity and momentum equations

68. Answer D

Solution

Explanation of each match:

A. Cavitation → 2 (Fluid pressure reduces to vapour pressure)

- Cavitation occurs when the local fluid pressure drops to (or below) the vapour pressure of the liquid at that temperature, causing vapour-filled cavities/bubbles to form in the flow — typically at points of high velocity/low pressure (e.g., pump impellers, turbine blades, venturi throats).

B. Separation → 4 (Adverse pressure gradient in widening boundaries of flow)

- Flow separation happens when the boundary layer encounters an **adverse pressure gradient** (pressure increasing in the direction of flow), typically in diverging/widening passages. This decelerates the flow near the wall until it reverses direction, causing the main flow to detach from the boundary.

C. Stagnation point → 1 (Absence of fluid velocity)

- A stagnation point is where the local fluid velocity becomes exactly **zero** — it occurs where a streamline meets a solid boundary head-on (e.g., front of a bluff body), with all kinetic energy converted to pressure energy.

D. Wake → 3 (Bluff body in flow)

- A wake is the region of disturbed, low-pressure, often turbulent/recirculating flow that forms **behind a bluff body** due to flow separation — bluff bodies (like spheres, cylinders) don't allow the flow to follow their surface smoothly around the back.

69. Answer D

Solution

- **Non-modular outlet** - Outlet discharge depends on the water levels in both the supply canal as well as the receiving water course.
- **Semi-modular outlet** - Outlet discharge depends only on the water level in the supply canal.
- **Modular outlet** - Outlet discharge is fixed and is independent of the water levels in both the supply canal as well as the receiving water course.

70. Answer B

Solution

- Aquifer - stores and yields water in sufficient quantity
- Aquiclude - stores but does not yield water
- Aquitard - stores water but yields little
- Aquifuge - neither stores nor yields water

71. Answer D

Solution

Following are the main causes of water-logging

- Excessive rainfall in the area
- Flat ground profile
- Seepage of water from canals and the adjoining lands
- Improper drainage of surface runoff
- Excessive irrigation

72. **Answer A**

Solution

$$\text{Exit Gradient} = \frac{H}{d} \times \frac{1}{\pi\sqrt{\lambda}}$$

$$\lambda = \frac{1+\sqrt{1+\alpha^2}}{2}$$

$$\alpha = \frac{b}{d} = \frac{60}{6} = 10$$

$$\therefore \lambda = \frac{1+\sqrt{1+10^2}}{2} = 5.525$$

$$\therefore \text{Exit Gradient} = \frac{6}{6\times\pi\sqrt{5.525}}$$

$$= 0.135$$

73. **Answer B**

Solution

The total drag on A will be larger than on B

Total drag = Pressure drag (form drag) + Skin friction drag

In laminar flow (low Reynolds number regime):

1. At low Re, **pressure drag is negligible** for both bodies — flow separation is minimal or absent, so there's very little wake formation, and hence very little pressure difference between front and rear.
2. In this regime, **skin friction (viscous) drag dominates** the total drag:

$$F_{D,total} \approx F_{D,friction}$$

3. Skin friction drag depends directly on the **wetted surface area** exposed to the flow:

$$F_{D,friction} \propto \mu \times (\text{wetted surface area}) \times (\text{velocity gradient at surface})$$

Comparing the two shapes (same maximum cross-sectional/frontal area):

- A **streamlined body (A)** is elongated with a tapering shape — for the *same frontal area*, it has a much **larger wetted surface area** than a compact sphere.
- A **sphere (B)** is the most compact shape possible for a given cross-sectional area — it has the **smallest possible surface area** enclosing that volume/cross-section.

So in laminar flow, since pressure drag is negligible for both, and skin friction dominates:

$$F_{D,A} > F_{D,B}$$

because the streamlined body's much larger wetted area leads to more total skin friction drag.

Why this differs from the "usual" intuition:

At **high Reynolds numbers** (turbulent boundary layer, bluff-body flow regime), streamlining greatly helps because pressure drag (from wake separation) dominates, and a streamlined shape drastically reduces the wake — this is the regime where **A would have much smaller drag than B** (like aircraft, cars, etc.).

But since this question specifically states **laminar flow**, pressure drag is not the dominant factor, so skin friction (driven by wetted area) controls the outcome instead — flipping the usual result.

So, the correct answer is (b) The total drag on A will be larger than on B.

74. **Answer C**

Solution

The Navier–Stokes equations are the general equations of motion for a **real (viscous) fluid,** derived by including viscous shear stress terms in Newton's second law applied to a fluid element. They govern both laminar and turbulent flow of viscous fluids.

Brief distinction from the other options:

(a) **Euler's equations —** apply to ideal (inviscid, frictionless) fluid flow; they're actually a special case of Navier–Stokes with viscosity set to zero.

(b) **Bernoulli equation** — an integrated form of Euler's equation along a streamline for ideal fluid flow (energy conservation), not a general equation of motion.

(d) **Hagen–Poiseuille equation** — a specific solution of the Navier–Stokes equations for steady, laminar flow through a circular pipe, not the general equation itself.

So, the Navier–Stokes equations are the fundamental governing equations for **laminar (and turbulent) flow of real, viscous fluids.**

75. Answer D

Solution

For laminar flow through a circular pipe, the Darcy friction factor is given by:

$$f = \frac{64}{Re}$$

Since f is inversely proportional to Reynolds number, f decreases as Re increases. However, laminar flow only exists up to the **critical Reynolds number,** Re_critical ≈ 2000 (beyond this, flow transitions to turbulent).

So the **minimum value of f** occurs at the **maximum Re** for which laminar flow can still exist, i.e., at Re = 2000:

$$f_{min} = \frac{64}{2000} = 0.032$$

76. Answer B

Solution

HFL of Drain = Drain Bed level + Depth of flow

= 116 + 10

HFL of Drain = 126

Bottom of canal = 120

The HFL of drain is higher than the canal bed so that the water passes through the aqueduct barrels under symphonic action, SO appropriate drainage drainage works to this site is syphon aqueduct

77. Answer B

Solution

Total rainfall = Intensity of rainfall-Duration

= 1.5 × 6 = 9 cm

Volume of runoff = 21.6×10^6 m³

Area of the basin = 300km² = 300×10^6 m²

$$\text{Depth of runoff} = \frac{\text{Vol. of runoff}}{\text{Area of the basin}}$$

$$= \frac{21.6\times10^6}{300\times10^6} = 0.072\,\text{m}$$

$$\text{Intensity of runoff} = \frac{0.072\times1000}{6} = 12\,\text{mm/hr}$$

$$\text{Infiltration rate} = (15-12)\,\text{mm/hr}$$

$$= 3\,\text{mm/hr}$$

78. Answer D

Solution

For steady, uniform, horizontal laminar flow, the Navier–Stokes equation reduces to a simple balance between the pressure force and the viscous shear force on a fluid element (since there's no acceleration — uniform flow means no change in velocity profile along the flow direction, and steady means no change with time).

This balance is expressed as:

$$\frac{\partial p}{\partial x} = \frac{\partial \tau}{\partial y}$$

where:

x = direction of flow (longitudinal)

y = normal direction (perpendicular to flow, e.g., across the pipe/channel)

τ = shear stress

79. Answer D

Solution

The wall shear stress relates to the (Darcy) friction factor by:

$$\tau_0 = \frac{f\rho V^2}{8}$$

Substituting values:

f = 0.02

ρ = 1.2 kg/m³

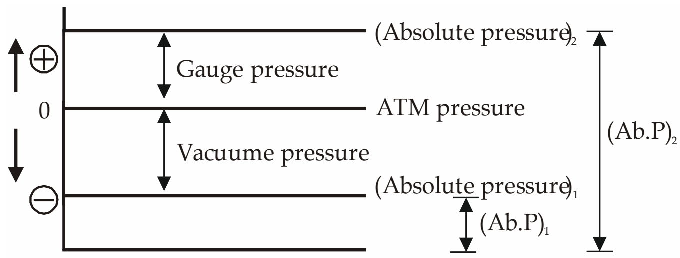
V = 20 m/s

$$\tau_0 = \frac{0.02\times1.2\times(20)^2}{8} = \frac{0.02\times1.2\times400}{8}$$

$$= \frac{9.6}{8} = 1.2\,\text{Pa}$$

80. Answer A

Solution



Gauge pressure : Absolute pressure - Atmospheric pressure

Vaccum pressure : Atmospheric pressure – Absolute pressure