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ESE – CIVIL ENGINEERING (Vol. – II)

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FLOW OF FLUIDS, HYDRAULIC MACHINES & HYDRO POWER

SECTION 1

SYLLABUS

(a) Fluid Mechanics, Open Channel Flow, Pipe Flow:

Fluid properties; Dimensional Analysis & Modeling; Fluid dynamics including flow kinematics and measurements; Flow net; Viscosity, Boundary layer and control, Drag, Lift, Principles in open channel flow, Flow controls. Hydraulic jump; Surges; Pipe networks.

(b) Hydraulic Machines and Hydro power -

Various pumps, Air vessels, Hydraulic turbines – types, classifications & performance parameters; Power house – classification and layout, storage, pondage, control of supply.



NUMBER OF QUESTIONS ASKED IN ESE CIVIL ENGINEERING VOLUME-II (2001 TO 2025)

FLOW OF FLUIDS, HYDRAULIC MACHINES AND HYDRO POWER		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1.1	Fluid Mechanics, Open Channel Flow, Pipe Flow																									
1.1.1	Properties of Fluids	1	1	2	1	1	1	1	-	-	2	4	-	1		1	2	-	3	1	-	1	2	-	1	-
1.1.2	Measurement of Pressure (Manometry)	-	-	-	-	-	2	-	1	-	-	1		1	1	-	-	-	-	-	-	3	-	-	1	2
1.1.3	Hydrostatic Force Analysis	-	1	1	-	-	-	-	-	-	-	-	1	-	-	1	1	-	-	-	2	-	1	1	-	1
1.1.4	Principles of Buoyancy and Floatation	1	-	1	1	-	-	-	-	1	-	-	-	1	1	1	2	1	-	1	-	-	-	-	1	1
1.1.5	Kinematics of Fluids	-	-	3	-	-	-	1	1	1	1	-	-	-	-	-	2	1	2	-	1	1	-	1	-	-
1.1.6	Fluid Dynamics and Flow Measurement	1	1	1	-	1	2	1	-	1	1	1	-	5	1	1	3	1	3	1	-	1	-	1	1	2
1.1.7	Viscous Flow of Incompressible Fluids	1	1	-	1	1	-	2	-	2	1	-	2	2	1	-	1	-	-	-	-	-	-	1	-	-
1.1.8	Flow in Pipes	2	3	4	1		3	-	2	3	3	3	5	4	1	2	5	1	2		-	1	2	3	1	2
1.1.9	Drag and Lift Analysis	3	1	-	-	-	2	2	-	2	1	2	1	5	1	-	1	1	1	2	2	1	-	2	-	-
1.1.10	Theory of Boundary Layer	1	1	1	1	1	2	1	1	-	-	1	2	1	1	-	2	-	2	-	-	-	2	-	-	-
1.1.11	Turbulent Flow Analysis	-	-	-	-	-	-	-	1	-	1	1	1	-	1	2	-	-	-	-	-	-	-	1	1	-
1.1.12	Dimensional and Model Analysis	-	1	1	-	1	1	2	1	-	1	1	-	5	1	2	1	2	-	-	1	-	-	-	-	-
1.1.13	Flow in Open Channels	2	7	7	4	3	6	13	3	3	4	3	6	5	5	4	8	3	9	1	2	-	1	1	2	-
1.2	Hydraulic Machines and Hydro power																									
1.2.1	Measurement by Notches and Weirs	1	-	2	-	-	-	-	-	1	-	4	-	2	-	1	1	-	1	-	-	-	-	3	-	-
1.2.2	Effects of Jets and Turbine Action	1	5	3	3	-	3	1	2	-	1	4	5	5	3	3	7	4	5	2	2	3	2	-	3	2
1.2.3	Pump Systems	-	3	1	3	2	3	2	2	4	5	4	7	3	2	4	3	2	3	2	2	2	2	1	2	5

CHAPTER-1

FLOW OF FLUIDS, HYDRAULIC MACHINES AND HYDRO POWER

Unit 1.1: Fluid Mechanics, Open Channel Flow, Pipe Flow

1.1.1 Properties of Fluids

Previous Year Exam Questions

[ESE: 2001]

1. Match List-I with List-II and select the correct answer using the codes given below the lists:

List-I	List-II
A. Concentrated sugar solution	1. Dilatant fluid
B. Sewage sludge	2. Bingham plastic fluid
C. Blood	3. Pseudo-plastic fluid
D. Air	4. Newtonian fluid

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	1	2	4	3
(c)	2	1	3	4
(d)	2	1	4	3

[ESE: 2002]

2. Match List-I (Definitions) with List-II (Properties) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Newtonian fluid	1. Frictionless and incompressible
B. Ideal fluid	2. Viscosity is invariant with shear stress
C. Thixotropic fluid	3. Viscosity decreases at higher shear stress
D. Rheological fluid	4. Viscosity increases at higher shear stress

Codes:

	A	B	C	D
(a)	2	4	1	3
(b)	3	1	4	2
(c)	2	1	3	4
(d)	3	4	1	2

[ESE: 2003]

3. Which one of the following statements is correct?

(a) Dynamic viscosity of water is nearly 50 times that of air.

(b) Kinematic viscosity of water is 30 times that of air.

(c) Water in soil is able to rise a considerable distance above the groundwater table due to viscosity.

(d) Vapour pressure of a liquid is inversely proportional to the temperature

[ESE: 2003]

4. Which of the following fluids can be classified as non-Newtonian?

1. Kerosene oil
2. Diesel oil
3. Human blood
4. Toothpaste
5. Water

Select the correct answer using the codes given below:

(a) 1 and 2 (b) 3 and 4

(c) 2 and 5 (d) 1 and 5

[ESE: 2004]

5. Assertion (A): At the standard temperature, the kinematic viscosity of air is greater than that of water at the same temperature.

Reason (R): The dynamic viscosity of air at standard temperature is lower than that of water at the same temperature.

(a) both A and R are true and R is the correct explanation of A

(b) both A and R are true but R is not a correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

[ESE: 2005]

6. The velocity distribution for flow over a plate is given by $u = 0.5y - Y^2$ where 'u' is the velocity in m/s at a distance 'y' meter above the plate. If the dynamic viscosity of the fluid is 0.9 N-s/m², then what is the shear stress at 0.20 m from the boundary?

(a) 0.9 N/m² (b) 1.8 N/m²

(c) 2.25 N/m² (d) 0.09 N/m²

[ESE: 2006]

7. A flat plate of 0.15 m² is pulled at 20 cm/s relative to another plate, fixed at a distance of 0.02 cm from it with a fluid having $\mu = 0.0014$ N-s/m² separating them. What is the power required to maintain the motion?

(a) 0.014 W (b) 0.021 W
(c) 0.035 W (d) 0.042 W

[ESE: 2007]

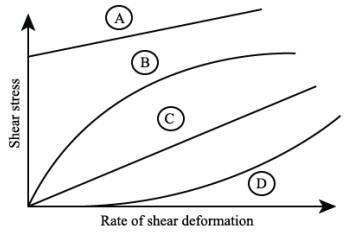
8. Which one of the following expresses the height of rise or fall of a liquid in a capillary tube?

(a) $\frac{4wd}{\sigma\cos\alpha}$ (b) $\frac{\sigma\cos\alpha}{4w\alpha}$
(c) $\frac{4\sigma\cos\alpha}{wd}$ (d) $\frac{wd}{4\sigma\cos\alpha}$

where,
$w =$ Specific weight of the liquid
$\alpha =$ Angle of contact of the liquid surface
$\sigma =$ Surface tension

[ESE: 2010]

9. Match List-I (Curve identification in figure) with List-II (Nature of fluid) and select the correct answer using the codes given below the lists:



List-I	List-II
A. Curve A	1. Newtonian
B. Curve B	2. Dilatant
C. Curve C	3. Ideal bingham plastic
D. Curve D	4. Pseudo-plastic

Codes:

	A	B	C	D
(a)	3	4	1	2
(b)	2	4	1	3
(c)	3	1	4	2
(d)	2	1	4	3

[ESE: 2010]

10. Assertion (A): The movement of two blocks of wood welted with hot glue requires greater and greater effort as the glue is drying up.
Reason (R): Viscosity of liquids varies inversely with temperature.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE: 2011]

11. Match List-I with List-II and select the correct answer using the code given below the lists:

List-I	List-II
A. Specific Gravity	1. $M^{\circ}L^{2}T^{-1}$
B. Coefficient of viscosity	2. $M^{\circ}L^{\circ}T^{\circ}$
C. Kinematic viscosity	3. $ML^{-1}T^{-1}$
D. Stress	4. $ML^{-1}T^{-2}$

Code:

	A	B	C	D
(a)	2	3	1	4
(b)	4	3	1	2
(c)	2	1	3	4
(d)	4	1	3	2

[ESE: 2011]

12. Poise has the unit of

(a) Dyne-cm/ S^2 (b) Dyne-cm/s
(c) Dyne-s/cm (d) Dyne-s/cm^2

[ESE: 2011]

13. Which one of the following statements is correct?

(a) For water at 100° Celsius at sea level, the vapour pressure is equal to atmospheric pressure.
(b) Surface energy (or tension) is caused by the force of adhesion between liquid molecules.
(c) Viscosity of a fluid is the property exhibited by it both in static and in dynamic conditions.
(d) Air is 50, 000 times more compressible than water.

[ESE: 2011]

14. Which one of the following statements is correct?

(a) Dynamic viscosity is the property of a fluid which is not in motion
(b) Surface energy is fluid property giving rise to the phenomenon of capillarity in water
(c) Cavitation results from the action of very high pressure
(d) Real fluids have lower viscosity than ideal fluids

[ESE: 2013]

15. Statement (I): As temperature increases, viscosity of air decreases.
Statement (II): As temperature increases, activity of the air molecules increases.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but Statement (II) true is

[ESE: 2015]

16. The surface tension in a soap bubble of 50 mm diameter with its inside pressure being 2.5 N/m² above the atmospheric pressure is

(a) 0.0125 N/m (b) 0.0156 N/m
(c) 0.2 N/m (d) 0.0312 N/m

[ESE: 2016]

17. The surface tension of water at 20°C is 75 x 10^{-3} N/m. The difference in water surfaces within and outside an open-ended capillary tube of 1 mm internal bore, inserted at the water surface, would nearly be

(a) 7 mm (b) 11 mm
(c) 15 mm (d) 19 mm

[ESE: 2016]

18. Statement (I): The shear strain graph for a Newtonian fluid is linear.
Statement (II): The coefficient of viscocity μ of the fluid is not constant.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but Statement (II) is true

[ESE: 2018]

19. The surface tension in a soap bubble of 20 mm diameter, when the inside pressure is 2·0 N/m² above atmospheric pressure, is

(a) 0·025 N/m (b) 0·0125 N/m
(c) 5 × 10^{-3} N/m (d) 4·25 × 10^{-3} N/m

[ESE: 2018]

20. A jet of water has a diameter of 0·3 cm. The absolute surface tension of water is 0·072 N/m and atmospheric pressure is 101·2 kN/m². The absolute pressure within the jet of water will be

(a) 101·104 kN/m² (b) 101·152 kN/m²
(c) 101·248 kN/m² (d) 101·296 kN/m²

[ESE: 2018]

21. A glass tube of 2·5 mm internal diameter is immersed in oil of mass density 940 kg/m³ to a depth of 9 mm. If a pressure of 148 N/m² is needed to form a bubble which is just released, what is the surface tension of the oil?

(a) 0·041 N/m (b) 0·043 N/m
(c) 0·046 N/m (d) 0·050 N/m

[ESE: 2019]

22. A plate 0.025 mm distant from a fixed plate moves at $60\ \text{cm/s}$ and requires a force of $0.2\ \text{kgf/m}^2$ to maintain this speed. The dynamic viscosity of the fluid between the plates will be nearly

(a) $9.2 \times 10^{-10}\ \text{kgfs/cm}^2$
(b) $8.3 \times 10^{-10}\ \text{kgfs/cm}^2$
(c) $7.4 \times 10^{-10}\ \text{kgfs/cm}^2$
(d) $6.5 \times 10^{-10}\ \text{kgfs/cm}^2$

[ESE: 2021]

23. What is the minimum size of glass tube that can be used to measure water level if the capillary rise in the tube is to be restricted to 2 mm? (Take surface tension of water in contact with air as $0.073575\ \text{N/m}$)

(a) 1.5 cm (b) 1.0 cm
(c) 2.5 cm (d) 2.0 cm

[ESE: 2022]

24. The pressure outside the droplet of water of diameter 0.04 mm is 10.32 N/cm^2 (atmospheric pressure). What is the pressure within the droplet if surface tension is $0.0725\ \text{N/m}$ of water?

(a) $11.045\ \text{N/cm}^2$ (b) $10.32\ \text{N/cm}^2$
(c) $9.45\ \text{N/cm}^2$ (d) $8.595\ \text{N/cm}^2$

[ESE: 2022]

25. What is the viscosity of a liquid whose kinematic viscosity is 6 stokes and specific gravity is 1.90?

(a) 1.14 poise (b) 11.40 poise
(c) $0.114\ \text{Ns/m}^2$ (d) $11.40\ \text{Ns/m}^2$

[ESE: 2024]

26. How does the bulk modulus of elasticity of a fluid change with increasing pressure?

(a) It remains constant
(b) It decreases with increase in pressure
(c) It increases with increase in pressure
(d) It becomes zero

ANSWER KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(a)	(c)	(a)	(b)	(b)	(d)	(d)	(c)	(a)	(a)
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
(a)	(d)	(a)	(b)	(d)	(b)	(c)	(c)	(c)	(c)
21	**22**	**23**	**24**	**25**	**26**				
(a)	(b)	(a)	(a)	(b)	(c)				

EXPLANATIONS

1. Explanation: (a)

Concentrated sugar solution is a dilatant fluid.

Sewage sludge is a Bingham plastic fluid.

Blood is a pseudo-plastic fluid.

Air is a Newtonian fluid.

Correct matching: A–1, B–2, C–3, D–4

2. Explanation: (c)

Newtonian fluid has viscosity invariant with shear stress.

Ideal fluid is frictionless and incompressible.

Thixotropic fluid shows decreasing viscosity with increasing shear stress.

Rheological fluid shows increasing viscosity with increasing shear stress.

Correct matching: A–2, B–1, C–3, D–4

3. Explanation: (a)

1. The dynamic viscosity of water is approximately 50 to 55 times that of air at 20°C.
2. The kinematic viscosity of air is nearly 15 times that of water.
3. Water in soil rises due to capillary action, not viscosity.
4. Vapour pressure increases with temperature.

Hence, option (a) is correct.

4. Explanation: (b)

Human blood and toothpaste are non-Newtonian fluids.

Kerosene oil, diesel oil, and water are Newtonian fluids.

Correct answer: 3 and 4

5. Explanation: (b)

Kinematic viscosity of air is greater than that of water at the same temperature.

Dynamic viscosity of air is lower than that of water.

However, the reason is not the correct explanation, since kinematic viscosity also depends on density, and air has much lower density than water.

Therefore, both A and R are true, but R is not the correct explanation of A.

6. Explanation: (d)

Given:

$u = 0.5y - y^2$

To find shear stress at $y = 0.20$ m, use:

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

$$\frac{du}{dy} = 0.5 - 2y$$

At $y = 0.2$ m:

$\tau = 0.9 \times (0.5 - 2 \times 0.2)$

$= 0.9 \times 0.1 = 0.09$ N/m^2

7. Explanation: (d)

Given:

Velocity $v = 0.2$ m/s , distance between plates $dy = 0.02 \times 10^{-2}$ m , viscosity $\mu = 0.0014$ N·s/m^2, area $A = 0.15$ m^2

Shear stress:

$$\tau = \mu \frac{du}{dy} = 0.0014 \times \frac{0.2}{0.0002}$$

$= 1.4$ N/m^2

Force:

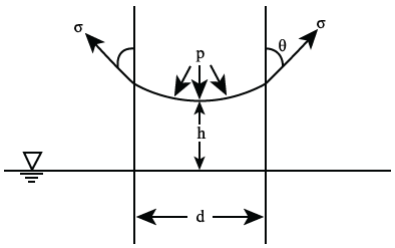
$F = \tau \times A = 1.4 \times 0.15 = 0.21$ N

Power:

$P = F \times v = 0.21 \times 0.2 = 0.042$ W

8. Explanation: (c)

Equating weight of the liquid column to vertical component of surface tension:

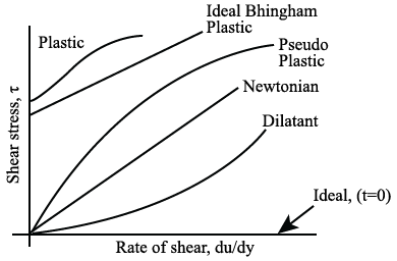


$$\frac{w\pi d^2}{4} \cdot h = \pi d\sigma \cos\alpha$$

Solving for h:

$$h = \frac{4\sigma\cos\alpha}{wd}$$

9. Explanation: (a)



Matching curves with fluid types:

Curve A → Ideal Bingham plastic (3)

Curve B → Pseudo-plastic (4)

Curve C → Newtonian (1)

Curve D → Dilatant (2)

Correct code: A–3, B–4, C–1, D–2

10. Explanation: (a)

As the glue dries and cools, its viscosity increases.

This increase in viscosity leads to greater resistance to motion.

Viscosity of liquids is inversely proportional to temperature, i.e.:

$$\mu \propto \frac{1}{T}$$

Therefore, both assertion and reason are true, and R correctly explains A.

11. Explanation: (a)

Specific gravity is a ratio and has no dimensions:

$$\Rightarrow M^0L^0T^0$$

Coefficient of viscosity (μ):

$$\text{Unit} = \frac{\text{N·s}}{\text{m}^2} = \frac{MLT^{-2} \cdot T}{L^2}$$

$$= ML^{-1}T^{-1}$$

Kinematic viscosity (ν):

$$\nu = \frac{\mu}{\rho}, \text{Unit} = \frac{\text{m}^2}{\text{s}} = L^2T^{-1}$$

Stress:

$$\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{MLT^{-2}}{L^2}$$

$$= ML^{-1}T^{-2}$$

Correct matching: A–2, B–3, C–1, D–4

12. Explanation: (d)

Poise is the CGS unit of dynamic viscosity:

$$1 \text{ Poise} = \frac{\text{dyne} \cdot \text{s}}{\text{cm}^2}$$

13. Explanation: (a)

At 100°C, water's vapour pressure equals atmospheric pressure.

Surface tension arises due to cohesion, not adhesion.

Air is about 20,000 times more compressible than water, not 50,000.

Therefore, option (a) is correct.

14. Explanation: (b)

Dynamic viscosity is the property of fluids in motion.

Surface energy gives rise to capillary action.

Cavitation is caused by very low (not high) pressures.

Real fluids have higher viscosity than ideal fluids (which are assumed to have none).

Therefore, option (b) is correct.

15. Explanation: (d)

Statement I is false: as temperature increases, viscosity of air **increases**, not decreases.

Statement II is true: activity of air molecules increases with temperature.

Therefore, option (d) is correct.

16. Explanation: (b)

Pressure difference inside a soap bubble:

$$\Delta p = \frac{8\sigma}{d} \Rightarrow \sigma = \frac{p \cdot d}{8}$$

Given:

$p = 2.5\ \text{N/m}^2, d = 0.05\ \text{m}$

$$\sigma = \frac{2.5 \times 0.05}{8} = 0.0156\ \text{N/m}$$

17. Explanation: (c)

Capillary rise:

$$h = \frac{2\sigma\cos\theta}{\rho g R}$$

Assuming $\cos\theta = 1$, $\rho = 1000\ \text{kg/m}^3$, $R = 1\ \text{mm} = 1 \times 10^{-3}\ \text{m}$, $g = 9.81\ \text{m/s}^2$, $\sigma = 75 \times 10^{-3}\ \text{N/m}$

$$h = \frac{2 \times 75 \times 10^{-3}}{1000 \times 9.81 \times 1 \times 10^{-3}} = 15.29\ \text{mm}$$

18. Explanation: (c)

For Newtonian fluids, the shear stress vs. shear rate graph is linear. This means the coefficient of viscosity μ is constant.

Therefore, Statement I is true, but Statement II is false.

19. Explanation: (c)

For a soap bubble, the excess pressure inside the bubble is related to surface tension T and radius R by:

$$\Delta P = \frac{4T}{R}$$

Given:

$\Delta P = 2.0\ \text{N/m}^2$, diameter $= 20\ \text{mm} = 0.02\ \text{m} \Rightarrow R = 0.01\ \text{m}$

Rearranging for T:

$$T = \frac{\Delta P \times R}{4} = \frac{2 \times 0.01}{4} = 5 \times 10^{-3}\ \text{N/m}$$

20. Explanation: (c)

For a jet of water, the increase in pressure inside the jet due to surface tension is

$$\Delta P = \frac{\sigma}{R}$$

where,

$\sigma = 0.072\ \text{N/m}$ (surface tension)

Diameter $d = 0.3\ \text{cm} = 0.003\ \text{m}$

Radius $R = \frac{d}{2} = 0.0015\ \text{m}$

The pressure difference:

$$\Delta P = \frac{0.072}{0.0015} = 48\ \text{N/m}^2 = 0.048\ \text{kPa}$$

The absolute atmospheric pressure is 101.2 kPa, so the absolute pressure inside the jet is:

$$P_{\text{absolute}} = 101.2 + 0.048 = 101.248\ \text{kPa}$$

21. Explanation: (a)

Given:

Internal diameter of glass tube $d = 2.5\ \text{mm} = 2.5 \times 10^{-3}\ \text{m}$

Radius $R = \frac{d}{2} = 1.25 \times 10^{-3}\ \text{m}$

Depth $h = 9\ \text{mm} = 0.009\ \text{m}$

Density of oil $\rho = 940\ \text{kg/m}^3$

Pressure needed to form bubble $\Delta P_{\text{total}} = 148\ \text{N/m}^2$

The hydrostatic pressure due to oil column:

$$P_{\text{hydro}} = \rho g h = 940 \times 9.81 \times 0.009 = 82.99\ \text{N/m}^2$$

The pressure due to surface tension is:

$$\Delta P = \Delta P_{\text{total}} - P_{\text{hydro}} = 148 - 82.99 = 65.01\ \text{N/m}^2$$

Using the formula for pressure difference at bubble formation:

$$\Delta P = \frac{2\sigma}{R}$$

$$\sigma = \frac{\Delta P \times R}{2} = \frac{65.01 \times 1.25 \times 10^{-3}}{2} = 0.04063\ \text{N/m}$$

22. Explanation: (b)

To calculate the dynamic viscosity (μ) of the fluid between the plates, we use the formula:

$$\tau = \mu \frac{V}{H}$$

The force per unit area ($\frac{F}{A}$) is given as 0.2 kgf/m². We can convert this into the appropriate units in the equation.

$$\frac{F}{A} = 0.2\ \text{kgf/m}^2 = \frac{\mu}{10^4} \frac{60}{0.025 \times 10^{-1}}$$

$$\mu = 8.3 \times 10^{-10}\ \text{kgfs/cm}^2$$

Thus, the dynamic viscosity of the fluid is 8.3×10^{-10} kgfs/cm^2, so the correct answer is (b).

23. Explanation: (a)

The capillary rise is

$$h = \frac{2\sigma\cos\theta}{\rho g R}$$

Where,

$h = 2\ \text{mm} = 2 \times 10^{-3}\ \text{m}$

$\sigma = 0.073575\ \text{N/m}$ (surface tension of water in contact with air)

$\rho = 1000\ \text{kg/m}^3$

$g = 9.81\ \text{m/s}^2$

$R =$?, capillary radius

$\cos\theta \approx 1$ (for water in clean glass tube)

$$R = \frac{2\sigma\cos\theta}{\rho g h}$$

$$R = \frac{2 \times 0.073575}{1000 \times 9.81 \times 2 \times 10^{-3}}$$
$$= 7.5 \times 10^{-3} \text{ m}$$
$$D = 2R = 2 \times 7.5 \times 10^{-3}$$
$$= 15 \times 10^{-3} \text{ m} = 1.5 \text{ cm}$$

24. Explanation: (a)

Given:

Diameter $d = 0.04$ mm $= 0.04 \times 10^{-3}$ m,

Radius $R = 0.02 \times 10^{-3}$ m,

Surface tension $\sigma = 0.0725$ N/m,

External pressure $P_o = 10.32$ N/cm^2

$$\Delta P = \frac{2\sigma}{R} = \frac{2 \times 0.0725}{0.02 \times 10^{-3}}$$
$$= 7250 \text{ N/m}^2 = 0.725 \text{ N/cm}^2$$
$$P_i = P_o + \Delta P = 10.32 + 0.725$$
$$= 11.045 \text{ N/cm}^2$$

25. Explanation: (b)

Given:

Kinematic viscosity $\nu = 6$ stokes $= 6 \times 10^{-4}$ m$^2/s$,

Specific gravity $S_g = 1.9$

$\rho_{water} = 1000$ kg/m^3

$$\rho_l = S_g \times \rho_{water} = 1.9 \times 1000$$
$$= 1900 \text{ kg/m}^3$$
$$\mu = \nu \times \rho = (6 \times 10^{-4}) \times (1900)$$
$$= 1.14 \text{ Ns/m}^2$$
$$\mu = 1.14 \times 10 = 11.4 \text{ poise}$$

26. Explanation: (c)

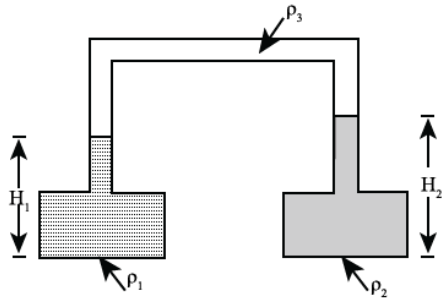
The bulk modulus of elasticity increases with pressure, as the material becomes more resistant to changes in volume with increasing external pressure.

1.1.2 Measurement of Pressure (Manometry)

Previous Year Exam Questions

[ESE: 2006]

1. Which one of the following expresses the difference in the pressure at the floors of the tank shown above in the figure?



(a) $(\rho_2 - \rho_1)gH_2$

(b) $(\rho_2 - \rho_1)gH_1$

(c) $\rho_1 gH_1 + \rho_3 gH_2 - \rho_2 gH_2$

(d) $\rho_1 gH_1 + \rho_3 g(H_2 - H_1) - \rho_2 gH_2]$

where ρ_1, ρ_2 and ρ_3 are the densities of the different fluids.

[ESE: 2006]

2. Multi U-tube manometers with different fluids are used to measure

(a) low pressures

(b) medium pressures

(c) high pressures

(d) very low pressures

[ESE: 2008]

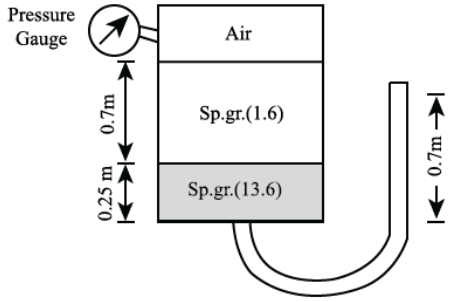
3. A pressure gauge reads 57.4 kPa and 80 kPa. respectively at heights of 8 m and 5 m fitted on the side of a tank filled with liquid. What is the approximate density of the liquid in $\mathbf{g/m^3}$?

(a) 393 (b) 768

(c) 1179 (d) 7530

[ESE: 2011]

4. In the below figure the pressure gauge will record a gauge pressure equivalent to



(a) 6.12 m of water (b) 1.21 m of mercury

(c) 0.5 bar (d) 34,000 Pa

[ESE: 2013]

5. The absolute pressure at a point 2.5 m below the clear water surface is measured as $\mathbf{125.703 kN/m^2}$. If the atmospheric pressure is taken as $\mathbf{101.325 kN/m^2}$, the gauge pressure in $\mathbf{kN/m^2}$ at this point would be

(a) 113.514 (b) 24.378

(c) 45.401 (d) 56.757

[ESE: 2014]

6. The standard atmospheric pressure is 101.32 kPa . The local atmospheric pressure is 91.52 kPa . If a pressure at a flow path is recorded at 22.48 kPa (gauge), it is equivalent to

(a) 69.04 kPa (abs) (b) 88.4 kPa (abs)

(c) 114.0 kPa (abs) (d) 123.0 kPa (abs)

[ESE: 2021]

7. What is the depth of a point below water surface in sea, where pressure intensity is $\mathbf{.006 MN/m^2}$? (Specific gravity of sea water is 1.025)

(a) 60 m (b) 80 m

(c) 100 m (d) 120 m

[ESE: 2021]

8. Two pressure points in a water pipe are connected to a manometer which has the form of an inverted U-tube. The space above the water in the two limbs of the manometer is filled with toluene (specific gravity is 0.875). If the difference of level of water columns in the two limbs reads 12.0 cm , what is the corresponding difference of pressure ? (Take $g = 9.81\ m/s^2$)

(a) $110 \cdot 49\ N/m^2$ (b) $128 \cdot 12\ N/m^2$

(c) $131 \cdot 34\ N/m^2$ (d) $147 \cdot 15\ N/m^2$

[ESE: 2021]

9. If pressure head of water is 100 m and specific gravity of kerosene is 0.81 , what is the pressure head of kerosene?

(a) 123.5 m of kerosene

(b) 241.3 m of kerosene

(c) 75.1 m of kerosene

(d) $52 \cdot 4$ m of kerosene

[ESE: 2024]

10. If V_s is the velocity of the vector, r is the radius of curvature and $\frac{\partial V_n}{\partial t}$ is the local normal acceleration; what is the expression for total normal acceleration of fluid particles?

(a) $\frac{dV_n}{dt} = V_s^2 + r\frac{\partial V_n}{\partial t}$ (b) $\frac{dV_n}{dt} = \frac{V_s^2}{r} + \frac{\partial V_n}{\partial t}$

(c) $\frac{dV_n}{dt} = r + V_s^2\frac{\partial V_n}{\partial t}$ (d) $\frac{dV_n}{dt} = \frac{r}{V_s^2} + \frac{\partial V_n}{\partial t}$

[ESE: 2025]

11. Which one of the following pressure gauges is the most accurate device and is used for precision work and calibrating other pressure gauges?

(a) Deadweight pressure gauge

(b) Diaphragm pressure gauge

(c) Bourdon tube pressure gauge

(d) Vacuum pressure gauge

[ESE: 2025]

12. Pitot tube is one of the most accurate devices for

(a) pressure measurement

(b) velocity measurement

(c) density measurement

(d) surface tension measurement

ANSWER KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(d)	(c)	(b)	(c)	(b)	(c)	(c)	(d)	(a)	(b)
11	**12**								
(a)	(b)								

EXPLANATIONS

1. Explanation: (d)

Applying pressure balance:

$p_1 - \rho_1 g H_1 - \rho_3 g(H_2 - H_1) + \rho_2 g H_2 = p_2$

Then,

$p_1 - p_2 = \rho_1 g H_1 + \rho_3 g(H_2 - H_1) - \rho_2 g H_2$

2. Explanation: (c)

For high pressures, a single U-tube manometer becomes too tall. Therefore, multi U-tube manometers with different fluids are used to keep the size reasonable while measuring high pressures.

3. Explanation: (b)

Given:

$p_1 = 57.4$ kPa, $p_2 = 80$ kPa, $h_1 = 8$ m, $h_2 = 5$ m

Using:

$p_2 - p_1 = \rho g(h_1 - h_2)$

$80 \times 10^3 - 57.4 \times 10^3 = \rho \times 9.81 \times 3$

$22600 = \rho \times 29.43$

$\rho = \frac{22600}{29.43} \approx 768\ kg/m^3$

4. Explanation: (c)

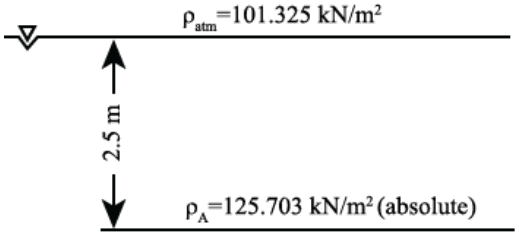
Let gauge pressure be P. Applying pressure balance:

$P + 1.6\rho_w g \times 0.7 + 13.6\rho_w g \times 0.25 - 13.6\rho_w g \times 0.7 = 0$

Then,

$P = 5\rho_w g = 5 \times 9.81 \times 1000 = 50000\ Pa = 0.5\ bar$

5. Explanation: (b)



Gauge pressure = Absolute pressure – Atmospheric pressure

$= 125.703 - 101.325 = 24.378\ kN/m^2$

6. Explanation: (c)

Absolute pressure = Local atmospheric pressure + Gauge pressure

$= 91.52 + 22.48 = 114.00$ kPa

7. Explanation: (c)

The hydrostatic pressure,

$$P = \rho_{sw} \cdot g \cdot h$$

Where,

$P = 1.006 \times 10^6$ Pa

$\rho_{sw} = 1.025 \times 10^3\ kg/m^3$ (density of seawater)

$g = 9.81\ m/s^2$

$h = ?$

Rearranging for h:

$$P_e = C_1 \times \left(\frac{\alpha_h}{g}\right) \times \rho_w \times g \times h$$

$$P_e = C_1 \times \alpha_h \times \rho_w \times h$$

2.2.6 Canal Conveyance Structures & Outlet Modules

Previous Year Exam Questions

[ESE: 2001]

1. Gibb's module is a type of outlet which ensures

(a) constant discharge even if the water levels in the supply channel and water course fluctuate

(b) variable discharge as per the need

(c) constant discharge into the water course when the water levels in the supply channel vary

(d) constant discharge for varying water levels in the water course for a given water level in the supply channel

[ESE: 2001]

2. The following data pertain to a natural drain crossing an irrigation canal:

Item	Canal data	Drainage data
Flow (m^3/s)	5	500
Bed level (m)	120	116
Depth of flow (m)	0.8	10

Which one of the following types of cross-drainage should be recommended in this case?

(a) Aqueduct (b) Syphon aqueduct

(c) Syphon (d) Super-passage

[ESE: 2002]

3. Modular limit of a canal outlet is the ratio of

(a) rate of change of discharge of outlet to that of distributary.

(b) water depth above outlet crest to the full supply depth of the channel

(c) water depth above the crest on downstream to that on upstream of outlet

(d) rate of change of discharge of an outlet to the rate of change of water level of the channel.

[ESE: 2002]

4. A canal fall is a control structure

(a) located at a place where the country slope is flatter than the canal bed slope

(b) located most economically where the depth of cutting is less than the balancing depth

(c) the location of which is independent of the command to be served

(d) designed to secure raising of water surface on its upstream

[ESE: 2003]

5. Assertion (A): Canal escape serves as a safety valve for a canal.

Reason (R): Canal escape discharges the excess water in the parent canal due to sudden closure of outlets by the farmers.

(a) both A and R are true and R is the correct explanation of A

(b) both A and R are true but R is not a correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

[ESE: 2003]

6. The worst condition of uplift on the floor of a syphon aqueduct occurs when there is

(a) high flood flow in the drainage with canal dry

(b) full supply flow in the canal with drainage dry

(c) high flood flow in the drainage with canal running full

(d) Water is at drainage bed and canal is dry

[ESE: 2005]

7. Match List-I (Relative position of canal and drainage channel) with List-II (Type of cross drainage work) and select the correct answer using the code given below the lists:

List-I	List-II
A. Canal taken above the drainage channel at its grade	1. Canal siphon
B. Drainage channel taken above the canal at its bed slope	2. Drainage siphon
C. Canal taken below the drainage channel	3. Aqueduct
D. Drainage channel taken below the canal	4. Super passage

Codes:

	A	B	C	D
(a)	2	4	1	3
(b)	3	1	4	2
(c)	2	1	4	3
(d)	3	4	1	2

[ESE: 2006]

8. What type of cross drainage work is provided when the canal runs below the drain, with FSL of canal well below the bed of the drain?

(a) Aqueduct (b) Super passage

(c) Level crossing (d) Siphon aqueduct

[ESE: 2006]

9. Which type of fall can be generally used for a moderate discharge of 40-60 cumecs and low fall heights of 1 to 1.5 m?

(a) Vertical drop fall (b) Ogee fall
(c) Glacis fall (d) Baffle fall

[ESE: 2006]

10. If the sensitivity of an irrigation module is 0.5 , then what percent variation in outlet discharge will be caused by 50 per cent variation in canal water depth?

(a) 100% (b) 50%
(c) 25% (d) 12.5%

[ESE: 2007]

11. Consider the following statements:
An aqueduct is a cross drainage work in which
1. a canal is carried over the drainage channel.
2. a drainage channel is carried over the canal.
3. both drainage channel and canal are at the same level.

Which of these statements is/are correct?

(a) 1 only (b) 1 and 2 only
(c) 2 and 3 only (d) 1, 2 and 3

[ESE: 2007]

12. What are the recommended setting options of an adjustable proportional module worked with an open flume type outlet?

1. 3/10 2. 9/10
3. 1/2 4. 5/3

Select the correct answer using the codes given below:

(a) 1 and 2 (b) 1 and 3
(c) 3 and 4 (d) 2 and 4

[ESE: 2008]

13. Semi-module outlets are those outlets in which
(a) discharge gets affected by the change in water level of field channel
(b) discharge gets affected by the change in water level of the distributing channel but not with the change in water level of field channel
(c) discharge is independent of water levels in the distributing channel and the field channel
(d) None of the above

[ESE: 2010]

14. A submerged pipe outlet is an example of
(a) semi-modular outlet
(b) non-modular outlet
(c) rigid module
(d) adjustable proportional module

[ESE: 2011]

15. Consider the following statements:
1. In a super-passage, the drain runs over the canal.
2. In a siphon, the drain runs below the canal.
3. In a siphon aqueduct, type-II, the canal banks are made of RCC walls.

Which of these statements are correct?

(a) 1 only (b) 1 and 2 only
(c) 2 and 3 only (d) 1 and 3 only

[ESE: 2011]

16. Flexibility of an outlet may be defined as the ratio of the rate of change of
(a) Outlet discharge to the rate of change of water level of the parent channel
(b) Outlet discharge to the rate of change of the discharge of the parent channel
(c) Parent channel discharge to the rate of change of the outlet discharge
(d) Parent channel water level to the rate of change of the outlet discharge

[ESE: 2011]

17. Consider the following statements:
Mitra's hyperbolic transition design is based on the principle that
1. Flow depth in the canal, as well as the discharge, is constant
2. Width of the canal varies along with the discharge
3. Rate of change of velocity per unit length of transition is constant throughout the length of the transition

Which of these statements are correct?

(a) 1, 2 and 3 (b) 1 and 2 only
(c) 2 and 3 only (d) 1 and 3 only

[ESE: 2014]

18. If the channel index at an irrigation outlet is 5/3, "setting" of an orifice type outlet in order to have proportionality is

(a) 0.90 (b) 0.67
(c) 0.30 (d) 0.15

[ESE: 2014]

19. Which of the following outlets are of semi-modular type?
1. Khanna's module
2. Adjustable proportional module
3. Submerged pipe outlet
4. Open flume outlet
5. Kennedy's gauge outlet

(a) 2, 4 and 5 (b) 1, 2 and 4
(c) 2, 3 and 5 (d) 3, 4 and 5

[ESE: 2015]

20. By considering the channel index as $5/3$, the setting of an orifice type irrigation outlet to have proportionality is

(a) 0.90 (b) 0.67

(c) 0.30 (d) 0.15

[ESE: 2018]

21. In a siphon, the summit is 5 m above the water level in the tank from which the flow is being discharged. If the head loss from the inlet to the summit is 2.5 m and the velocity head at the summit is 0.5 m , (taking $\gamma = 10$ appropriate units) the pressure head at the summit is

(a) -80 kPa (b) -3 m of water (abs)

(c) 5 m of water (abs) (d) 18 m of water (abs)

[ESE: 2019]

22. Consider the following data for a drain:

$L = 50\ m, a = 10\ m, b = 10.3\ m$, and $k = 1 \times 10^{-5}\ m/s$

If the drains carry 1% of average annual rainfall in 24 hrs , the average annual rainfall for which this system has been designed will be

(a) 78 cm (b) 84 cm

(c) 90 cm (d) 96 cm

[ESE: 2023]

23. Statement (I): Cross drainage structure, aqueduct is constructed to negotiate an aligned channel over, below or at the same level of a stream.

Statement (II): Aqueduct is constructed when full supply level (FSL) of canal is much higher than high flood level (HFL) of a stream.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)

(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I)

(c) Statement (I) is true but Statement (II) is false

(d) Statement (I) is false but Statement (II) is true

ANSWER KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(a)	(b)	(c)	(d)	(a)	(b)	(d)	(b)	(c)	(c)
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
(a)	(a)	(b)	(b)	(d)	(b)	(d)	(c)	(a)	(c)
21	**22**	**23**							
(a)	(*)	(d)							

EXPLANATIONS

1. Explanation: (a)

Gibb's module is a rigid module that maintains constant discharge within specified limits, regardless of fluctuations in water levels in both the supply channel and water course. This ensures reliable water distribution independent of varying hydraulic conditions.

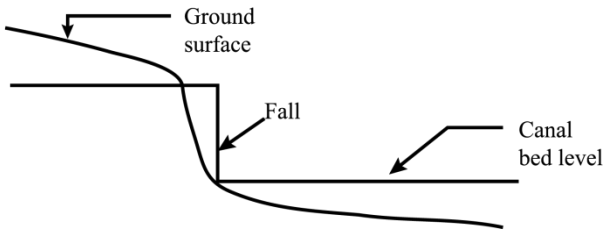
2. Explanation: (b)

The drainage bed level (116 m) plus flow depth (10 m) gives HFL of 126 m, which is higher than the canal bed level (120 m). A siphon aqueduct is recommended when the drainage HFL exceeds the canal bed level, allowing the canal to cross over the drain with proper hydraulic design.

3. Explanation: (c)

The modular limit refers to extreme values of hydraulic variables beyond which an outlet cannot function as a module or semi-module. It represents the ratio of downstream water depth above outlet crest to upstream water depth above crest, defining the operational range for modular flow conditions.

4. Explanation: (d)



Canal falls are control structures designed to secure raising of water surface on the upstream side when natural ground slope is steeper than the designed canal bed slope. The location is determined by topography, command requirements, and economic considerations for combining with other structures.

5. Explanation: (a)

Canal escapes function as safety valves by discharging excess water from the parent canal. This occurs during sudden closure of outlets by farmers or flood conditions, preventing canal submergence and maintaining system stability. The reason correctly explains the assertion.

6. Explanation: (b)

The worst uplift condition occurs when the canal runs full with no water in the drainage. Maximum uplift due to seepage occurs when hydrostatic pressure from full canal supply creates maximum head

differential across the floor with dry drainage conditions below.

7. Explanation: (d)

Cross-drainage works are classified by relative positions:

- Canal above drainage at grade: Aqueduct (A-3)
- Drainage above canal at bed slope: Super passage (B-4)
- Canal below drainage: Canal siphon (C-1)
- Drainage below canal: Drainage siphon (D-2)

8. Explanation: (b)

When the canal FSL is well below the drain bed level, a super passage is provided. This structure carries the drainage channel over the canal, allowing the drain to maintain its natural gradient while the canal flows beneath.

9. Explanation: (c)

Glacis falls are suitable for moderate discharges of 40-60 cumecs and low fall heights of 1-1.5 m. The hydraulic jump on the glacis provides adequate energy dissipation, making it appropriate for these flow conditions and can be designed with flumes for flow measurement.

10. Explanation: (c)

Sensitivity is defined as:

$$S = \frac{(dq/q)}{(dy/y)}$$

Given: $S = 0.5$ and $dy/y = 50\%$

$$\frac{dq}{q} = \frac{dy}{y} \times S = 50\% \times 0.5 = 25\%$$

11. Explanation: (a)

An aqueduct is specifically a cross-drainage work where the canal is carried over the drainage channel. Super passages carry drainage over canals, and level crossings allow water intermixing. Only the first statement correctly defines an aqueduct.

12. Explanation: (a)

For adjustable proportional modules with open flume outlets:

- Orifice type outlet: Setting = $\frac{1/2}{5/3} = \frac{3}{10} = 0.3$
- Weir type outlet: Setting = $\frac{3/2}{5/3} = \frac{9}{10} = 0.9$

The recommended settings are 3/10 and 9/10.

13. Explanation: (b)

Semi-modular outlets have discharge that depends only on the distributing channel water level, remaining independent of field channel water level variations, provided minimum working head is maintained. This provides partial flow control compared to fully modular outlets.

14. Explanation: (b)

A submerged pipe outlet is a non-modular outlet where discharge depends on the head difference between the distributary and water course. The flow varies with water level fluctuations in both channels.

15. Explanation: (d)

In a super-passage, the drain runs over the canal. In siphon aqueduct Type-II, canal banks are replaced by RCC retaining walls while maintaining earthen sections. Siphons actually have canals running below drains, not the reverse.

16. Explanation: (b)

Flexibility is defined as the ratio of the rate of change of outlet discharge to the rate of change of discharge of the parent channel. When flexibility equals one, the outlet is termed proportional.

17. Explanation: (d)

Mitra's hyperbolic transition design maintains constant flow depth and assumes constant rate of change of velocity per unit length throughout the transition. The width varies with velocity changes, not with discharge directly.

18. Explanation: (c)

For orifice type outlet with channel index $n = 5/3$:

Outlet index $m = 1/2$

$$\text{Setting} = \frac{m}{n} = \frac{1/2}{5/3} = \frac{3}{10} = 0.30$$

19. Explanation: (a)

Semi-modular outlets include:

- Adjustable proportional module
- Open flume outlet
- Kennedy's gauge outlet (Venturi-flume outlet)

These outlets maintain discharge independence from field channel levels while depending on distributary levels.

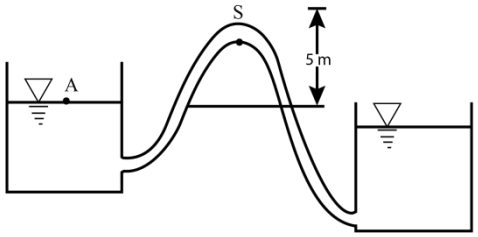
20. Explanation: (c)

For proportional flow with channel index $5/3$:

$$\text{Setting} = \frac{\text{Outlet index}}{\text{Channel index}} = \frac{1/2}{5/3} = 0.30$$

This ensures proportional discharge relationship between outlet and channel flows.

21. Explanation: (a)



ENVIRONMENTAL ENGINEERING

SECTION 3

SYLLABUS

(a) Water Supply Engineering:

Sources, Estimation, quality standards and testing of water and their treatment; Rural, Institutional and industrial water supply; Physical, chemical & biological characteristics and sources of water, Pollutants in water and its effects, Estimation of water demand; Drinking water Standards, Water Treatment Plants, Water distribution networks..

(b) Waste Water Engineering:

Planning & design of domestic waste water, sewage collection & disposal; Plumbing Systems. Components & layout of sewerage system; Planning & design of Domestic Waste-water disposal system; Sludge management including treatment, disposal & re-use of treated effluents; Industrial waste waters & Effluent Treatment Plants including institutional and industrial sewage management.

(c) Solid Waste Management:

Sources & classification of solid wastes along with planning & design of its management system; Disposal system, Beneficial aspects of wastes and Utilization by Civil Engineers.

(d) Air, Noise pollution and Ecology:

Concepts & general methodology.



NUMBER OF QUESTIONS ASKED IN ESE CIVIL ENGINEERING VOLUME-II (2000 TO 2025)

ENVIRONMENTAL ENGINEERING		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
3.1	Water Supply Engineering																										
3.1.1	Estimation of Water Demand	-	-	1	1	1	-	1	-	2	-	-	-	-	-	1	1	1	-	-	-	1	1	5	-	4	-
3.1.2	Water Sources and Well Systems	-	1	2	3	2	2	-	1	-	1	2	-	5	2	4	2	2	2	2	1	1	1	-	2	4	-
3.1.3	Assessment of Water Quality Parameters	-	2	1	-	2	2	6	3	1	4	-	2	10	2	1	1	3	-	2	1	-	-	5	1	1	1
3.1.4	Water Treatment Processes	-	6	1	4	8	6	6	4	1	4	5	8	4	4	7	7	4	6	3	3	2	2	4	1	2	-
3.1.5	Water Conveyance and Distribution	-	3	2	1	2	2	-	1	3	-	2	1	-	1	-	3	-	-	1	-	1	-	-	1	2	1
3.2	Waste Water Engineering																										
3.2.1	Biochemical Reactions in Wastewater	-	-	-	-	1	1	-	1	-	1	1	1	-	-	1	-	-	1	-	-	-	2	-	1	-	1
3.2.2	Wastewater Quality Characteristics	-	2	2	-	2	1	3	-	-	1	1	2	2	1	4	1	-	1	1	2	1	-	1	2	1	1
3.2.3	Effluent Disposal Methods	-	2	-	1	1	2	-	1	1	2	-	1	1	-	-	-	2	-	1	1	1	-	-	-	-	1
3.2.4	Wastewater Treatment Techniques	-	5	3	5	3	6	-	3	4	3	4	6	2	6	4	5	5	1	3	2	1	4	-	5	2	2
3.2.5	Design of Sewer Networks and Sewerage Systems	-	3	-	2	5	-	-	-	2	-	-	1	2	5	1	-	1	1	-	1	-	1	-	-	-	-
3.3	Solid Waste Management																										
3.3.1	Municipal Solid Waste Management	-	3	2	3	-	2	-	4	4	1	-	-	1	1	-	3	1	1	3	1	-	-	-	-	-	-
3.4	Air, Noise pollution and Ecology																										
3.4.1	Air Pollution Control and Impact	-	2	6	2	2	4	1	2	4	4	1	1	4	2	3	5	4	2	2	2	1	-	1	-	-	2
3.4.2	Noise Pollution	-	1	-	-	1	2		1	1	-	1	-	1	2	-	1	-	-	-	-	3	-	-	-	-	-

CHAPTER-3 ENVIRONMENTAL ENGINEERING

Unit 3.1 Water Supply Engineering

3.1.1 Estimation of Water Demand

Previous Year Exam Questions

[ESE: 2002]

1. The population figures in a growing town are as follows:

Year	Population
1970	40,000
1980	46,000
1990	53,000
2000	58,000

The predicted population in 2010 by Arithmetic Regression method is

(a) 62,000 (b) 63,000
(c) 64,000 (d) 65,000

[ESE: 2003]

2. On which of the following factors, does the population growth in a town normally depend?

1. Birth and death rates
2. Migrations
3. Probabilistic growth
4. Logistic growth

Select the correct statements:

(a) 1 and 4 (b) 1 and 2
(c) 1, 2 and 3 (d) 2 and 3

[ESE: 2004]

3. Which one of the following Acts/Rules has a provision for "No right to appeal"?

(a) Environment (Protection) Act, 1986
(b) The Hazardous Waste (Management and Handling) Rules, 1989
(c) Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989
(d) Environment (Protection) Rules, 1992

[ESE: 2006]

4. The present population of a community is 28000 with an average water demand of 150 Lpcd . The existing water treatment plant has a design capacity of $6000\ m^3/d$. It is expected that the population will increase to 48000 during the next 20 years. What is the number of years from now when the plant will reach its design capacity assuming an arithmetic rate of population growth?

(a) 8.6 years (b) 12.0 years
(c) 15.0 years (d) 16.5 years

[ESE: 2008]

5. For water supply to a medium town, what is the daily variation factor?

(a) 1.5 (b) 2.5
(c) 3 (d) 3.5

[ESE: 2008]

6. Which one of the following factors has the maximum effect on figure of per capita demand of water supply of a given town?

(a) Method of charging of the consumption
(b) Quality of water
(c) System of supply-intermittent or continuous
(d) Industrial demand

[ESE: 2014]

7. Population levels over 5 decades of a small town are given below.

Year	Population
1960	2,50,00
1970	2,80,000
1980	3,40,000
1990	4,20,000
2000	4,90,000

The population of the town in the year 2020 estimated by Arithmetic Increase method will be

(a) 5,10,000 (b) 5,90,000
(c) 6,10,000 (d) 6,90,000

[ESE: 2015]

8. The population of a city in the year 2000 was 82,300. If average percent increase in population per decade in 35%, the population of the city in the year 2020 estimated by geometrical increase method will nearly be

(a) 100000 (b) 125000
(c) 150000 (d) 175000

[ESE: 2016]

9. A water supply distribution system for an averagely-populated township to be designed for

(a) Maximum daily demand
(b) Maximum hourly demand and fire demand
(c) Average demand
(d) Maximum daily demand and fire demand, or maximum hourly demand, whichever is higher

[ESE 2020]

10. In which one of the following industries, the water requirement in kilo litres per unit of production is very high?

(a) Paper industry
(b) Steel industry
(c) Sugar industry
(d) Fertilizer industry

[ESE 2021]

11. Statement (I):

Both the Empirical formulae given by American Insurance Association and Buston for the determination of fire demand of water are not suitable for Indian conditions.

Statement (II):

Kuichling's formula estimates lesser value of fire water demand.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but Statement (II) is true

[ESE 2022]

12. Which one of the following is NOT a factor affecting losses and wastes in water supply scheme?

(a) Metering
(b) Unauthorized connections
(c) Water demand
(d) Pressure in the distribution system

[ESE 2022]

13. Which one of the following forecasting methods for population is also known as uniform increase method?

(a) Arithmetic increase method
(b) Decreasing rate method
(c) Geometric increase method
(d) Simple geographical method

[ESE 2022]

14. In a big city having population of 50 lakhs, if 6 moderate fires each of 3 hours break out in a day, what is the approximate amount of water required per person per day? (Assume 3 jet streams simultaneously throwing water from a hydrant with discharge of 1100 litres/minute/stream)

(a) less than 1 litre
(b) between 1–3 litres
(c) between 3–5 litres
(d) 20 litres

[ESE 2022]

15. The various types of water demand, which a city may have, may be broken down into which of the following classes?

1. Domestic water demand
2. Industrial water demand
3. Demand for public uses

Select the correct answer using the code given below:

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

[ESE 2022]

16. For water supply scheme design of a town or a city, the suitable method of estimating future population by the end of the design period is

(a) increasing rate method
(b) decreasing rate method
(c) exponential curve method
(d) incremental decrease method

[ESE 2024]

17. Match the following lists:

List I (Type of commercial building/institution)	List II (Water demand in Litres per day)
P. Restaurants	1. 45 per capita
Q. Nurses homes and medical quarters	2. 70 per seat
R. Cinemas, concert halls and theatre	3. 135 per capita
S. Factories	4. 15 per seat

Select the correct answer using the code given below:

	P	Q	R	S
(a)	4	1	2	3
(b)	2	1	4	3
(c)	4	3	2	1
(d)	2	3	4	1

[ESE 2024]

18. If P is population of town/city, Q is total quantity of water required during one year for a town/city; what is the formula for maximum daily per capita demand for a town/city ?

(a) $18 \times \frac{Q}{P \times 365}$ (b) $18 \times \frac{Q}{P \times 24}$
(c) $1.5 \times \frac{Q}{P \times 365}$ (d) $1.5 \times \frac{Q}{P \times 24}$

[ESE 2024]

19. If $P_n =$ Population at the end of n decade, $P_o =$ Present population, $P_{gv} =$ Average arithmetic increase in the population (decadal), $P_I =$ Average

incremental increase in population, n = Number of decades; what is the mathematical representation of Incremental Increase Method?

(a) $P_n = P_l \times n + (P_{av} + P_o)$

(b) $P_n = P_l + (P_{av} + P_o) \times n$

(c) $P_n = P_o + (P_{av} + P_p) \times n$

(d) $P_n = P_o \times n + (P_{av} + P_f)$

[ESE 2024]

20. If Q is the water requirement in $\mathrm{L/min}$ and P is population in thousands, what. is Buston's formula to determine fire demand?

(a) $Q = 5663\sqrt{P}$

(b) $Q = 3182\sqrt{P}$

(c) $Q = 4637(1 - 0.01\sqrt{P})$

(d) $Q = 100\sqrt{P}$

ANSWER KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(c)	(b)	(a)	(b)	(b)	(d)	(c)	(c)	(d)	(a)
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
(b)	(c)	(a)	(a)	(d)	(b)	(d)	(a)	(c)	(a)

EXPLANATIONS

1. Explanation: (c)

The Arithmetic Regression method for population forecasting calculates the average increase per decade from historical data and applies it to predict future population. Using the given population data, we first determine the increase in population for each decade and then calculate the average increase.

Year	Population	Increase in Population (x)
1970	40,000	6,000
1980	46,000	7,000
1990	53,000	5,000
2000	58,000	
Total		**18,000**

Average increase per decade:

$$\bar{x} = \frac{18{,}000}{3} = 6{,}000$$

The future population is computed using the formula:

$$P_n = P_0 + n\bar{x}$$

Thus, population after 1 decade beyond 2000 i.e.:

$P_{2010} = P_{2000} + 1 \times 6{,}000 = 58{,}000 + 6{,}000$
$= 64{,}000$

2. Explanation: (b)

The factors that normally affect population growth in a town are:

Birth Rate: The number of live births per thousand of population per year.

Death Rate: The ratio of deaths to the population of a particular area or during a particular period of time, usually calculated as the number of deaths per one thousand people per year.

Migration: Migration also affects the number of deaths and births in an area. Migrations take into account emigration from and immigration to the city. These three factors - births, deaths, and migration - are the primary natural and demographic determinants that control actual population changes in urban areas.

3. Explanation: (a)

Section 22 of Environment (Protection) Act, 1986 has a provision for 'No right to appeal'. This section establishes that decisions made under this particular environmental legislation are final and cannot be challenged through appellate procedures.

4. Explanation: (b)

Method-1

Population after n years:

$P_n = P_0 + n\bar{x}$

where $\bar{x}$ is arithmetic design growth rate

Given: $P_0 = 28{,}000$

For $n = 20$; $P_{20} = 48{,}000$

Therefore: $\bar{x} = \frac{48{,}000 - 28{,}000}{20} = 1{,}000$ per year

The population when design capacity will be required:

$$P_n = \frac{6{,}000 \times 1{,}000}{150} = 40{,}000$$

Therefore, number of years to reach the plant at design capacity:

$$n = \frac{P_n - P_0}{\bar{x}} = \frac{40{,}000 - 28{,}000}{1{,}000} = 12.0 \text{ years}$$

Method-2

Given present population: $P_0 = 28{,}000$

Average water demand: $q = 150$ lpcd

Design capacity of existing water treatment plant: $6{,}000$ m^3/day

Total demand at present:

$= 28{,}000 \times 150 \times 10^{-3} = 4{,}200$ m^3/day

After 20 years (i.e., 2 decades) population (P_2) increased to 48,000

Therefore by Arithmetic increase method:

$P_2 = P_0 + 2 \times \bar{x}$

$48{,}000 = 28{,}000 + 2 \times \bar{x}$

$\bar{x} = 10{,}000$

Therefore average increase in population per decade = 10,000

Design capacity calculation:

$4{,}200$ m^3/day corresponds to $28{,}000$ population

6,000 m^3/day corresponds to $\frac{28,000}{4,200} \times 6,000 = 40,000$ population

Therefore: $P_n = P_0 + n\bar{x}$

$40,000 = 28,000 + n \times 10,000$

$n = 1.2$ decades ≈ 12 years

Therefore after 12 years plant will reach its design capacity.

5. Explanation: (b)

The GOI manual on water supply has recommended the following values of peak factor depending upon the population:

S.No.	Population	Peak factors
1	Up to 50,000 (small town)	3.0
2	50,001 - 2,00,000 (medium town)	2.5
3	Above 2 lakh (Large town)	2.0
4	For Rural water supply scheme (where supply is effected through standpost for only 6 hr)	3.0

(Based on old GOI manual data as it is an old question)

6. Explanation: (d)

The factors affecting per capita demand are:

(i) Size of the city

(ii) Climatic conditions

(iii) Types of gentry and habits of people

(iv) Industrial and commercial activities

(v) Quality of water supplies

(vi) Pressure in the distribution system

(vii) Development of sewerage facilities

(viii) System of supply

(ix) Cost of water

(x) Policy of metering and method of charging

Among the above factors, industrial and commercial activities have the maximum effect on per capita demand. The presence of industrial and commercial activities at a particular place increases the water consumption by large amounts. Many industries require really huge amounts of water and as such increase the water demand considerably.

7. Explanation: (c)

Using the Arithmetic Increase method to calculate population projection for 2020:

Year	Population	Increase in Population (x)
1960	250,000	30,000
1970	280,000	60,000
1980	340,000	80,000
1990	420,000	70,000
2000	490,000	
Total		**240,000**

Average increase per decade:

$$(\bar{x}) = \frac{240,000}{4} = 60,000$$

The future population are now computed by using:

$$P_n = P_0 + n\bar{x}$$

Thus population after 2 decades beyond 2000:

i.e., $P_{2020} = P_{2000} + 2 \times \bar{x}$

$= 490,000 + 2 \times 60,000 = 610,000$

8. Explanation: (c)

Estimation of population by geometrical increase method:

$$P_n = P_0\left(1 + \frac{r}{100}\right)^n$$

$$P_{2020} = P_{2000}\left(1 + \frac{35}{100}\right)^2$$

Where: $P_0 = 82,300$, $n = 2$, $r = 35\%$

$$= 82,300\left(1 + \frac{35}{100}\right)^2$$

$= 82,300 \times (1.35)^2 = 149,991.75 \simeq 150,000$

9. Explanation: (d)

Distribution system is to be designed for greater of maximum hourly demand or maximum daily demand and fire demand.

The design principle ensures that the water supply system can handle the most demanding flow conditions, whether they occur during peak hourly consumption or during the combination of maximum daily demand with fire fighting requirements.

Note: Coincident draft = Max. daily demand + Fire demand

10. Explanation: (a)

In the paper industry, the water requirement per unit of production is typically very high, as significant amounts of water are used in the pulp-making and paper production processes. Therefore, the correct answer is (a).

11. Explanation: (b)

Statement (I) is false because both the American Insurance Association and Buston's empirical formulae for determining fire demand water are not entirely suitable for Indian conditions, as they do not account for regional variations. Statement (II) is true, as Kuchling's formula does indeed provide more conservative estimates for fire water demand, making it more applicable in certain situations.

12. Explanation: (c)

Water demand represents consumption needs and does not directly contribute to losses or wastage in a water supply system. Factors like metering, unauthorized connections, and pressure variations affect losses.

13. Explanation: (a)

The arithmetic increase method assumes a constant population growth per unit time, expressed as:

$\frac{dP}{dt} = \text{Constant}$

Unlike the geometric increase method, which assumes a constant percentage growth, the arithmetic method follows a uniform increase pattern.

14. Explanation: (a)

Given:

Population = 50 lakh

No. of fires = 6, Duration per fire = 3 hours

Discharge per hydrant jet = 1100 L/min

Total jets per fire = 3

Total water required:

$3 \times 1100 \times 6 \times 3 \times 60 = 3.564 \times 10^6$ L

Per capita water demand:

$\frac{3.564 \times 10^6}{50 \times 10^6} = 0.7$ L/day

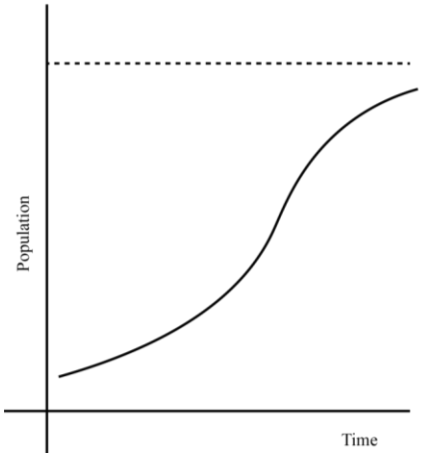
15. Explanation: (d)

The water demand of a city includes:

1. Domestic water demand
2. Industrial water demand
3. Public uses (firefighting, street washing, etc.)

16. Explanation: (b)

As cities develop, their population growth slows down. The decreasing rate method accounts for this gradual reduction in growth rate.



17. Explanation: (d)

Restaurants – 45 per capita

Nurses homes and medical quarters – 135 per capita

Cinemas, concert halls and theatres – 15 per seat

Factories – 70 per seat

18. Explanation: (a)

Formula for maximum daily per capita water demand

Max daily demand $= 1.8 \times \left(\frac{Q}{P \times 365}\right)$

19. Explanation: (c)

The Incremental Increase Method estimates future population using the formula

$P_n = P_0 + (P_{av} + P_i) \times n$

20. Explanation: (a)

Buston's formula to estimate fire demand is:

$Q = 5663\sqrt{P}$

3.1.2 Water Sources and Well Systems

Previous Year Exam Questions

[ESE: 2001]

1. Assertion (A): The available yield of a tubewell can be doubled by doubling the dlameter of the well. Reason (R): The yield of a tubewell varies inversely with the logarithm of the reciprocal of the diameter of the well.

(a) both A and R are true and R is the correct explanation of A

(b) both A and R are true but R is not a correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

[ESE: 2002]

2. Match List-I (Equation) with List-II (Applicability or principle of equation) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Theim's equation	1. is based on energy conservation principle
B. Dupit's assumption	2. is based on mass conservation principle
C. Bernoulli's equation	3. is applicable to steady flow towards a well in a confined aquifer
D. Continuity equation	4. is applicable to steady flow in an unconfined aquifer

Codes:

	A	B	C	D
(a)	4	3	2	1
(b)	3	4	2	1
(c)	4	3	1	2
(d)	3	4	1	2

[ESE: 2002]

3. The performance of a well is measured by its

(a) Specific capacity

(b) Specific yield

(c) Storage coefficient

(d) Permeability coefficient

[ESE: 2003]

4. Match List-I (Tests) with List-II (Features) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Pumping test	1. The gradual rise of water level in well is observed as time progresses
B. Recuperation Test	2. Rate of pumping is adjusted to constant leve of water in well
C. Pressure Test	3. Vigorous mixing of the chemical followed by slow mixing
D. Jar Test	4. Pipeline is filled up with water, allowed to stand for sometime and then at least double the maximum pressure is applied

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	2	1	4	3
(c)	1	2	4	3
(d)	2	1	3	4

[ESE: 2003]

5. Consider the following statements:

A well development

1. involves reversal of flow through the well screen
2. increases permeability towards the well
3. decreases permeability towards the well
4. is continued till sand/silt free water is pumped out

Which of these statements is/are correct?

(a) 1, 3 and 4

(b) 1, 2 and 4

(c) 3 only

(d) 1 and 4

[ESE: 2003]

6. Match List-I (Well hydraulics parameters) with List-II (Definition) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Specific yield	1. Discharge per unit drawdown of well
B. Safe yield	2. Same as specific retention
C. Specific capacity	3. Measure of water that can be removed by pumping
D. Field capacity	4. Limit of withdrawal from wellwithout depletion of the aquifer
	5. Water-bearing capacity of aquifer

Codes:

	A	B	C	D
(a)	4	3	2	5
(b)	3	4	1	2
(c)	4	3	1	2
(d)	3	4	2	5

[ESE: 2004]

7. Assertion (A): The yield of a well varied from $10\ \mathbf{m^3}/$ day to $20\ \mathbf{m^3}/$ day when the aquifer area changed from $50\ \mathbf{m^2}$ to $75\ \mathbf{m^2}$.

Reason (R): The yield is found to be directly proportional to the area of an aquifer opening into a well.

(a) both A and R are true and R is the correct explanation of A

(b) both A and R are true but R is not a correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

[ESE: 2004]

8. Which one of the following correctly defines aquiclude?

(a) A saturated formation of earth material which not only stores water but also yields it in sufficient quantity.

(b) A formation through which only seepage is possible and thus the yield is insignificant compared to an aquifer.

(c) A geological formation which is neither porous nor permeable.

(d) A geological formation which is essentially impermeable to the flow of water.

[ESE: 2005]

9. The discharge per unit drawdown at the well is known as

(a) Specific yield (b) Specific storage

(c) Specific retention (d) Specific capacity

[ESE: 2005]

10. Consider the following statements:

1. Infiltration galleries are placed along the river beds at a depth 4 to 6 m .
2. The draw-down for the infiltration galleries is more than that for radial wells.
3. Clogging of pipe pores in infiltration galleries is less than that for radial wells.
4. The cost of extracting unit volume of water is more in case of infiltration galleries as compared to radial wells.

Which of these statements is/are correct?

(a) 1 and 2 (b) 1, 2 and 3
(c) 2, 3 and 4 (d) 4 only

[ESE: 2007]

11. How is the determination of aquifer parameters S (Storage Coefficient) and T (Transmissivity Coefficient) done?

1. By recording the drawdown in a pumped well at different time intervals.
2. By recording the drawdown in installed observation wells at different time intervals.

Select the correct answer using the codes given below:

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

[ESE: 2009]

12. A groundwater basin consists of $10\ \text{km}^2$ area of plains. The maximum groundwater table fluctuation has been observed to be 1.5 m . Consider specific yield of the basin as 10%. What is the available groundwater storage in million cubic metres?

(a) 1.0 (b) 1.5
(c) 2.5 (d) 2.0

[ESE: 2010]

13. An unconfined aquifer of porosity 30%, permeability $35\ \text{m}$/ day and specific yield of 0.20 has an area of $100\ \text{km}^2$. If the water table falls by 0.25 m during a drought, the volume of water lost from storage, in million cubic metres, is

(a) 2.0 (b) 5.0
(c) 1.0 (d) 4.0

[ESE: 2010]

14. Assertion (A): In a strainer type tube well, strainer pipes are surrounded by wire mesh.
Reason (R): This prevents the fine particles from entering the well pipe.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE: 2012]

15. Statement-I: Rainwater is collected and harvested using storage structures like underground tanks for future use and also for recharging the aquifer.
Statement-II: Rainwater harvesting pits allow the rainwater to percolate and recharge the aquifer.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but Statement (II) is true

[ESE: 2012]

16. What would be the volume of water stored in a saturated column with a porosity of 0.35 with a cross-sectional area of $1\ \text{m}^2$ and depth of 3 m ?

(a) $2.0\ \text{m}^3$ (b) $0.105\ \text{m}^3$
(c) $1.05\ \text{m}^3$ (d) $3.0\ \text{m}^3$

[ESE: 2012]

17. The surface joining the static levels in several non-pumping wells penetrating a continuous confined aquifer represents

(a) Water table surface
(b) Capillary fringe
(c) Piezometric surface of the aquifer
(d) Physical top surface of the aquifer

[ESE: 2012]

18. Coefficient of permeability of an underground stratum is $0.001\ \text{m/s}$. Discharge obtained from a well of area $20\ \text{m}^2$ dug into this stratum (with drawdown of 2 m) will be

(a) 2400 lpm (b) 2000 lpm
(c) 1200 lpm (d) 1000 lpm

[ESE: 2012]

19. Statement-I: When a tube well penetrates into a homogenous aquifer and is then pumped, there will occur lowering of water surface. The resultant surface is designated as 'Drawdown curve'.
Statement-II: Since the pressure on the surface of the 'Drawdown curve' is always at atmospheric level, it is called by this name.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)

(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is NOT the correct explanation of Statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but Statement (II) is true

[ESE: 2013]

20. Due to a continuous pumping for 7 hrs from a catchment of 25 ha, having porosity of 30% and specific retention of 10%, groundwater level dropped by 1 m . The corresponding change in storage is:
(a) 7.5 ha-m (b) $0.75\ \text{ha} - \text{m}$
(c) $1.87\ \text{ha} - \text{m}$ (d) $0.187\ \text{ha} - \text{m}$

[ESE: 2013]

21. As recommended by Sichardt, the radius of influence is
(a) Inversely proportional to drawndown
(b) Linearly proportional to drawdown
(c) Independent of drawdown
(d) Proportional to square root of drawdown

[ESE: 2014]

22. When 3.5 million m^3 of water was pumped out from an unconfined aquifer of $6.3\ \text{km}^2$ areal extent, the water table was observed to go down by 2.5 m . The specific yield of the aquifer is best approximated as
(a) 32% (b) 28%
(c) 25% (d) 22%

[ESE: 2014]

23. An unconfined aquifer of porosity 35%, permeability $40\ \text{m}$/ day and specific yield of 0.15 has an area of $100\ \text{km}^2$. If the water table falls uniformly throughout the aquifer area by 0.2 m during a drought, the volume of water lost from.storage is
(a) $1.5\ \text{Mm}^3$ (b) $3.0\ \text{Mm}^3$
(c) $7.0\ \text{Mm}^3$ (d) $8.0\ \text{Mm}^3$

[ESE: 2014]

24. Ground water flows through an aquifer with a cross-sectional area of $1.0 \times 10^4\ \text{m}$ and a length of 1500 m. Hydraulic heads are 300 m and 250 m at the ground water entry and exit points in the aquifer respectively. Ground water discharge into stream at the rate of $1500\ \text{m}^3$/ day. The corresponding hydraulic conductivity of this aquifer will be
(a) 3.5 m/day (b) 4.5 m/day
(c) 5.0 m/day (d) 5.5 m/day

[ESE: 2014]

25. A tubewell of 30 cm diameter penetrates fully into an artesian aquifer. The artesian length is 15 m . The yield from the well under a drawdown of 3 m through the aquifer consisting of sand of effective size of 0.2 mm and coefficient of permeability of $50\ \text{m}$/ day , with radius of drawdown of 150 m , is nearly
(a) $240\ \text{l/s}$ (b) $120\ \text{l/s}$
(c) $24\ \text{l/s}$ (d) $12\ \text{l/s}$

[ESE: 2015]

26. In a uniform, semi-infinite aquifer, the dependable discharge of a lone circular open well is increased most easily by
(a) increasing the diameter
(b) making it into one with a square kerb
(c) deepening the well
(d) providing coarser screening filter

[ESE: 2015]

27. What is the strainer length required for a deep tube well giving a discharge of 8 litres per second? Assume permissible entrance velocity of $2\ \text{cm}$/ second. It is desired to have the strainer of slot sizes $20\ \text{mm} \times 0.2\ \text{mm}$ with number of slots per cm length of the strainer as 100.
(a) 8 m (b) 1 m
(c) 12 m (d) 10 m

[ESE: 2016]

28. Which of the following statement are correct as regards aquifer characteristics?
1. The storage coefficient is the volume of water released from storage from the entire aquifer due to unit depression of piezometric head.
2. The storage coefficient is the same as the specific yield for water table aquifer.
3. Both the aquifer constant, viz, storage coefficient S and Transmissivity T are dimensionless numbers.
(a) 1 only (b) 2 only
(c) 3 only (d) 1, 2 and 3

[ESE: 2016]

29. Consider the following assumptions as regards field permeability test:
1. The flow is laminar and Darcy's law is valid.
2. The flow is horizontal and uniform at all points in the vertical section.
3. The velocity of flow is proportional to the 'tangent magnitude' of the hydraulic gradient.

Which of the above assumptions are correct?
(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

[ESE 2017]

30. Consider the following statements in respect of ground water aquifers:

1. Specific storage is specific capacity per unit depth of the aquifer.
2. Specific capacity is storage coefficient per unit aquifer depth.
3. Specific capacity is a constant for a given well.
4. For one-dimensional flow in a confined aquifer between two water bodies, the piezometric head line in the aquifer is a straight line.

Which of the above statements are correct?

(a) 2 and 3 only (b) 2 and 4 only
(c) 1 and 3 only (d) 1 and 4 only

[ESE 2017]

31. For an unconfined aquifer, the specific yield is 20%, specific retention is 15%, and permeability is $35\ \mathrm{m}$/ day. Consider the following statements:

1. The porosity of the aquifer is 35%.
2. The transmissibility is $35\ \mathrm{m}^2$/ day.
3. The volume of water lost from storage per metre drop in the water table per $100\ \mathrm{km}^2$ area of the aquifer is 20 million m^3.

Which of the above statements are correct?

(a) 1 and 3 only (b) 1 and 2 only
(c) 2 and 3 only (d) 1, 2 and 3

[ESE 2018]

32. Which of the following situations can be attributed to sustained excessive groundwater pumping in a basin?

1. Drying up of small lakes and streams over a period in spite of normal rainfall
2. Deterioration of groundwater quality in certain aquifers
3. Land subsidence in the basin
4. Increase in seismic activity
5. Increased cost of groundwater extraction

Which of the above statements are correct?

(a) 2 and 4 only (b) 1, 2, 3 and 5 only
(c) 3 and 4 only (d) 1 and 5 only

[ESE 2018]

33. Groundwater flows through an aquifer with a cross-sectional area of 1.0×10^4 m² and a length of 1500 m. Hydraulic heads are 300 m and 250 m at the groundwater entry and exit points in the aquifer, respectively. Groundwater discharges into a stream at the rate of 750 m³/day. Then the hydraulic conductivity of the aquifer is

(a) 1·50 m/day (b) 2·25 m/day
(c) 3·50 m/day (d) 4·25 m/day

[ESE 2019]

34. The coefficient of transmissibility T for a confined aquifer can be determined by a pumping-out test together with other relevant observations. The applicable formula is (where $Q =$ Discharge, and $\Delta S =$ Difference in drawdowns in two wells)

(a) $\frac{Q}{2.72\Delta S}$ (b) $\frac{Q}{1.72\sqrt{\Delta S}}$
(c) $\frac{Q}{2.72}\Delta S$ (d) $\frac{Q}{2{\cdot}72}\sqrt{\Delta S}$

[ESE 2020]

35. The transition region between unsaturated zone and saturated zone is called

(a) Capillary fringe (b) Water table
(c) Yadose water zone (d) Confining bed

[ESE 2021]

36. In a groundwater field test, a tracer took 8 hours to travel between two observation wells which are 56 m apart. The difference in water table elevations in these wells was 0.70 m . The volume of the void of the aquifer is 30% of the total volume of the aquifer. What is the hydraulic conductivity of the aquifer, if the dynamic viscosity of water is $0.995 \times 10^{-3}\ \mathrm{Ns/m^2}$?

(a) $4 \cdot 664$ cm/s (b) 3.664 cm/hr
(c) 2.664 mm/s (d) 1.664 cm/hr

[ESE 2023]

37. A fully penetrating well in a confined sandy aquifer has a maximum discharge capacity of 1200 l/min. The aquifer is overlain and underlain by impervious formations. The thickness of the aquifer is 20 m. Assume the percentage of the open area of an available strainer to be 15% and bore hole diameter as 15 cm. What is the length of the well screen? (Take safe entrance velocity as 0.02 m/s)

(a) 10.5 m (b) 12.3 m
(c) 13.1 m (d) 14.1 m

[ESE 2023]

38. Which one of the following is the ability of a material to absorb moisture from air and thus to dissolve and become liquid?

(a) Deliquescence (b) Hygroscopicity
(c) Wilting (d) Capillarity

[ESE 2024]

39. Consider the following statements regarding quality difference of ground water and surface water:

1. The turbidity of ground water is high, whereas surface water is little.
2. Total dissolved solids of ground water is lower than surface water.
3. Concentration of inorganic compounds or ions of ground water is higher than surface water.

Which of the above statements is/are correct?

(a) 1 and 2 (b) 2 only
(c) 3 only (d) 1 and 3

[ESE 2024]

40. Consider the following statements regarding ground water:

1. Ground water is exhaustible and is evenly available.
2. Natural replenishment of the ground water resource is a very fast process.
3. Ground water is generally better than surface water in respect of biological characteristics.

Which of the above statements is/are correct?

(a) 1 and 3 only (b) 2 and 3 only
(c) 3 only (d) 1, 2, and 3

[ESE 2024]

41. Match the following lists:

List I (Material)	List II (Specific yield %)
P. Clay	1. 1.5 – 15
Q. Sand and grave	2. 15 – 25
R. Sandstone	3. 0.5 – 5
S. Limestone	4. 1 - 10

Select the correct answer using the code given below:

	P	Q	R	S
(a)	2	3	1	4
(b)	1	2	4	3
(c)	3	1	2	4
(d)	4	2	1	3

[ESE 2024]

42. A fully penetrating artesian well is pumped at a rate $Q = 1500\ \mathrm{m^3}/$ day from an aquifer whose storage coefficient and transmissivity are 4×10^{-4} and $0 - 145\ \mathrm{m^2/min}$, respectively. Considering $\omega(u) = 8.62$, what is the drawdowns at a distance 3 m from the production well after one hour of pumping?

(a) 8.62 m (b) 14.53 m
(c) 4.93 m (d) 2.38 m

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

EXPLANATIONS

1. Explanation: (d)

The yield of a tubewell cannot be doubled simply by doubling its diameter. The yield formula for wells shows that discharge is inversely proportional to the logarithm of the reciprocal of the well radius:

For unconfined aquifer:

$$Q = \frac{\pi K(d^2 - h_w^2)}{2.3\log_{10}(R/r_w)}$$

For confined aquifer:

$$Q = \frac{2\pi KH(D - h_w)}{2.3\log_{10}(R/r_w)}$$

Since yield varies inversely with the logarithm of the reciprocal of radius (diameter), doubling the diameter will not double the yield.

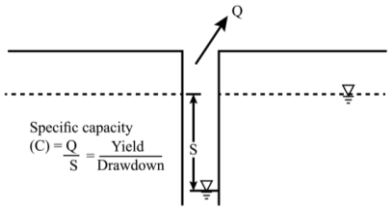
The reason is correct but the assertion is false.

2. Explanation: (d)

The equations are matched with their correct applications based on their fundamental principles:

1. Theim's equation applies to steady flow towards a well in a confined aquifer
2. Dupit's assumption is applicable to steady flow in an unconfined aquifer
3. Bernoulli's equation is based on energy conservation principle
4. Continuity equation is based on mass conservation principle

3. Explanation: (a)



Well performance is measured by specific capacity, which is defined as the discharge per unit drawdown at the well. It quantifies how efficiently a well can produce water for a given amount of water level decline.

4. Explanation: (b)

The tests are matched with their characteristic features:

1. Pumping test involves adjusting the rate of pumping to maintain constant water level in the well