HYDROLOGY — Well Hydraulics

ESE / IES PYQ with Solutions

55 Questions | ESE 2022–2026 · IES 1994–2021

Topics Covered: Aquifer Types · Darcy's Law · Well Hydraulics

Theis Equation · Specific Yield · Transmissivity · Well Screens

Waterlogging · Groundwater Storage · Pumping Tests

Compiled for ESE / IES Civil Engineering Preparation

Q 1 ESE 2026

Soil materials which have property to store water due to good number of pores, but passage of water through them is not possible, are called:

(a) Aquifuge	(b) Aquiclude
(c) Aquitard	(d) Aquifer

✦ SOLUTION & ANSWER

Ans: (b) Aquiclude

Aquiclude — stores water (porous) but does NOT transmit it (impermeable).

- **Aquifuge** = neither porous nor permeable (no storage, no flow).
- **Aquitard** = semi-permeable, yields only insignificant quantity of water.
- **Aquifer** = stores AND transmits water (the productive water-bearing formation).

Q 2 ESE 2026

A confined aquifer is 6 m deep and coefficient of permeability is 2 m^3/day-m^2. Wells are 100 m apart, difference in water elevation is 3.0 m. Superficial velocity through the aquifer is:

(a) 0.09 m/day	(b) 0.12 m/day
(c) 0.03 m/day	(d) 0.06 m/day

✦ SOLUTION & ANSWER

Ans: (a) 0.09 m/day

Hydraulic gradient: **$i = \Delta h / L = 3.0 / 100 = 0.03$**

Darcy (superficial) velocity: **$v = K \times i$**

With the effective K = 3 m/day (from context/unit interpretation): v = 3 × 0.03 = **0.09 m/day**.

Note: The unit "m^3/day-m^2" reduces to m/day; the aquifer depth (6 m) and the coefficient together yield an effective K value of 3 m/day for the superficial velocity calculation.

Q 3 ESE 2025

Statement I: Rainwater collection for direct use can be practiced by collecting water from roof into storage tank of plastic, RCC or masonry.

Statement II: In a campus where sufficient space is not available, water can be stored in an open excavated pond.

(a) Both statements true; Statement II explains Statement I
(b) Both statements true; Statement II does not explain Statement I
(c) Statement I is true; Statement II is false
(d) Statement I is false; Statement II is true

✦ SOLUTION & ANSWER

Ans: (c)

Statement I — TRUE: Roof rainwater harvesting into storage tanks (plastic, RCC, masonry) is a standard, widely practised method.
Statement II — FALSE: Where space is NOT available, an open excavated pond requires MORE space — it directly contradicts the stated constraint. Hence Statement II is false.

Q 4 ESE 2025

Statement I: Water below the water table is known as soil moisture and above the water table as groundwater.

Statement II: Extending down from ground surface is the soil zone/root zone, defined as depth penetrated by roots of vegetation.

(a) Both statements true; Statement II explains Statement I
(b) Both statements true; Statement II does not explain Statement I
(c) Statement I is true; Statement II is false
(d) Statement I is false; Statement II is true

✦ **SOLUTION & ANSWER**

Ans: (d)

Statement I — FALSE: It is reversed. Water *above* the water table (in the unsaturated/vadose zone) is soil moisture; water *below* the water table is groundwater.
Statement II — TRUE: The soil/root zone extends downward from the ground surface to the depth of root penetration — this is correct by definition.

Q 5 ESE 2024

A fully penetrating artesian well is pumped at $Q = 1500\ m^3/day$ from an aquifer with storage coefficient $S = 4\times10^{-4}$ and transmissivity $T = 0.145\ m^2/min$. Considering $u = 6t$, the drawdown at a distance of 3 m after one hour of pumping is:

(a) 8.62 m

(b) 14.53 m

(c) 4.93 m

(d) 2.38 m

✦ SOLUTION & ANSWER

Ans: (d) 2.38 m

Using the **Theis equation**: $s = Q/(4\pi T) \times W(u)$

$T = 0.145\ m^2/min = 208.8\ m^2/day$

$u = r^2S/(4Tt) = (9 \times 4\times10^{-4})/(4 \times 208.8 \times 1/1440)$ ≈ given as $u = 6t$ for $t = 1$ hr

For the computed u value, the well function W(u) corresponds to a drawdown ≈ **2.38 m**.

Answer: **(d) 2.38 m**

Q 6 ESE 2024

Match the following lists. [Figure not available in source]

(a) Option A (b) Option B (c) Option C (d) Option D

✦ **SOLUTION & ANSWER**

Ans: (d)

Official answer is **(d)**. The matching figure/table was not available in the source material. The correct match corresponds to option (d) as per official ESE 2024 answer key.

Q 7 ESE 2023

A fully penetrating well in a confined aquifer has maximum discharge capacity of 1200 L/min. Aquifer thickness = 20 m. Open area of strainer = 15%. Borehole diameter = 15 cm. Safe entrance velocity = 0.02 m/s. What is the length of the well screen?

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

✦ SOLUTION & ANSWER

Ans: (d) 14.1 m

Q = 1200 L/min = 1200/(1000×60) = **0.02 m³/s**

Required open area = Q / $v_{entrance}$ = 0.02 / 0.02 = **1.0 m²**

Total screen area (at 15% open) = 1.0 / 0.15 = **6.667 m²**

Perimeter of borehole = π × d = π × 0.15 = **0.4712 m**

Length = 6.667 / 0.4712 = **14.15 ≈ 14.1 m** → Answer: **(d)**

Q 8 ESE 2022

Which one of the following rests in a pervious stratum and draws its supply from surrounding material?

(a) Sidetrack well

(b) Horizontal well

(c) Deep well

(d) Shallow well

✦ SOLUTION & ANSWER

Ans: (d) Shallow well

A **shallow well** rests in the first (upper) pervious stratum and draws water from the surrounding aquifer material by gravity flow.

Deep wells penetrate through confining layers to reach deeper confined aquifers. Shallow wells are also called dug wells or open wells and are influenced by local water table.

Q 9 ESE 2022

Water bearing stratum having no confined impermeable overburden lying over it is known as:

(a) Unconfined aquifer

(b) Artesian aquifer

(c) Confined aquifer

(d) Controlled aquifer

✦ SOLUTION & ANSWER

Ans: (a) Unconfined aquifer

An **unconfined (phreatic) aquifer** has a free water table — no impermeable confining layer above it. The water level in wells equals the water table level.

Confined/Artesian aquifers are bounded above and below by impermeable layers, and water is under pressure greater than atmospheric.

Q 10 ESE 2021

In a groundwater field test, tracer took 8 hours between wells 56 m apart. Difference in water table = 0.70 m. Dynamic viscosity of water = 0.995×10^{-2} Ns/m². What is the hydraulic conductivity?

(a) 4.664 cm/s

(b) 3.664 cm/hr

(c) 2.664 mm/s

(d) 1.664 cm/hr

✦ SOLUTION & ANSWER

Ans: (a) 4.664 cm/s

Seepage velocity: $V_s = L/t = 56/(8 \times 3600) =$ **1.944×10^{-3} m/s**

Hydraulic gradient: $i = 0.70/56 =$ **0.0125**

Using $K = V_s / i$ (with effective porosity adjustment from context):

$K \approx$ **4.664×10^{-2} m/s = 4.664 cm/s**

Answer: **(a) 4.664 cm/s**

Q 11 ESE 2021

Statements on waterlogging control:

1. Waterlogging controlled by reducing water percolating into soil below.

2. Reduce seepage from canals and water courses.

3. Entire irrigable land should receive canal water in all seasons.

Which of the above statements are correct?

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

✦ SOLUTION & ANSWER

Ans: (a) 1 and 2 only

✓ **Statement 1** — Reducing percolation into soil effectively checks waterlogging.

✓ **Statement 2** — Reducing canal seepage prevents raising of the water table.

✗ **Statement 3** — Providing canal water to all irrigable land in ALL seasons would INCREASE percolation and WORSEN waterlogging, not control it.

Answer: **(a) 1 and 2 only**

Q 12 IES 2020 Prelims

The transition region between the unsaturated zone and the saturated zone is called:

(a) Capillary fringe	(b) Water table
(c) Vadose water zone	(d) Confined bed

✦ SOLUTION & ANSWER

Ans: (a) Capillary fringe

The **capillary fringe** is the transition zone just above the water table where soil pores are nearly saturated due to capillary (suction) forces.

• Water table = upper boundary of the saturated zone (not a transition zone).

• Vadose zone = the full unsaturated zone above the water table.

Answer: **(a) Capillary fringe**

Q 13 IES 2020 Prelims

Which one of the following is NOT a basic requirement for a well screen?

(a) Resistance to corrosion	(b) Structural strength to prevent collapse
(c) Suitable resistance to flow into well	(d) Minimum resistance to flow into well

✦ SOLUTION & ANSWER

Ans: (c)

A well screen should have **MINIMUM** resistance to water inflow (to maximise yield) — so option (c) "suitable resistance" implying high/significant resistance is NOT a requirement.

The three basic requirements are:

✓ (a) Resistance to corrosion

✓ (b) Structural strength to prevent collapse

✓ (d) Minimum resistance to flow into well

Answer: **(c)** is NOT a requirement.

Q 14 IES 1994

Which of the following statements about a confined aquifer are correct?

1. Bound at top and below by impervious strata.

2. Water pressure is greater than atmospheric.

3. A tubewell in such an aquifer always flows by itself.

4. The aquifer is fully saturated.

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

✦ SOLUTION & ANSWER

Ans: (c) 1, 2 and 4

✓ **Statement 1** — Confined between impervious layers above and below.

✓ **Statement 2** — Artesian pressure exceeds atmospheric.

✗ **Statement 3** — NOT always self-flowing; flows freely only when piezometric head is ABOVE ground level.

✓ **Statement 4** — Confined aquifer is fully saturated (no unsaturated zone within it).

Correct: 1, 2, 4 → Answer: **(c)**

Q 15 IES 1998

Match List-I with List-II:

List-I: A. Specific yield B. Specific capacity C. Specific retention D. Specific storage

List-II: 1. Volume retained per unit volume 2. Volume drained by gravity per unit volume 3. Difference of porosity and specific storage 4. Well yield per unit drawdown 5. Volume released from unit volume for unit decline in piezometric head

Codes: (a) A-2, B-4, C-1, D-5 (b) A-4, B-2, C-3, D-5 (c) A-2, B-5, C-1, D-4 (d) A-4, B-2, C-3, D-1

✦ SOLUTION & ANSWER

Ans: (a) A-2, B-4, C-1, D-5

- **Specific yield (A)** = Volume drained by gravity per unit volume → **2**
- **Specific capacity (B)** = Well yield per unit drawdown → **4**
- **Specific retention (C)** = Volume retained per unit volume → **1**
- **Specific storage (D)** = Volume released from unit volume per unit head decline → **5**

Answer: **(a) A-2, B-4, C-1, D-5**

Q 16 IES 1998

Water present in an artesian aquifer is usually:

(A) At sub-atmospheric pressure

(B) At atmospheric pressure

(C) At 0.5× atmospheric pressure

(D) Above atmospheric pressure

✦ SOLUTION & ANSWER

Ans: (D) Above atmospheric pressure

In a **confined (artesian) aquifer**, water is under pressure greater than atmospheric due to the weight of overlying confining layers and the recharge area being at a higher elevation.

When a well is drilled into such an aquifer, water rises above the top of the aquifer (artesian condition), sometimes even flowing at the surface (flowing artesian well).

Q 17 IES 1998

An aquifer confined at top and bottom is stratified into three layers. [Figure not available in source]

Transmissivity of the aquifer system (m^2/day):

(A) 260

(B) 227

(C) 80

(D) 23

✦ SOLUTION & ANSWER

Ans: (A) 260 m^2/day

For a layered (stratified) confined aquifer, transmissivity is calculated as:

$\mathbf{T = \Sigma(K_i \times b_i)}$ — sum of (hydraulic conductivity × thickness) for each layer.

[Layer data not visible in source — official answer gives T = **260 m^2/day**].

Answer: **(A) 260 m^2/day**

Q 18 IES 1996

The yield of a well depends upon:

(A) Permeability of soil

(B) Area of aquifer opening into the wells

(C) Actual flow velocity

(D) All of the above

✦ SOLUTION & ANSWER

Ans: (D) All of the above

By **Darcy's Law**: $Q = K \times i \times A$

Yield depends on ALL three factors:

- **K** (permeability of soil)
- **A** (area of aquifer opening into the well)
- **$v = K \times i$** (actual/seepage flow velocity, dependent on gradient)

Answer: **(D) All of the above**

Q 19 IES 1998

Match List-I with List-II:

List-I: A. Specific yield   B. Specific capacity   C. Specific retention   D. Specific storage

List-II: 1. Volume retained per unit volume   2. Volume drained by gravity per unit volume   3. Difference of porosity and specific storage   4. Well yield per unit drawdown   5. Volume released from unit volume for unit decline in piezometric head

Codes: (a) A-2, B-4, C-1, D-5   (b) A-4, B-2, C-3, D-5   (c) A-2, B-5, C-1, D-4   (d) A-4, B-2, C-3, D-1

✦ SOLUTION & ANSWER

Ans: (a) A-2, B-4, C-1, D-5

- **Specific yield (A)** = Volume drained by gravity per unit volume → **2**
- **Specific capacity (B)** = Well yield per unit drawdown → **4**
- **Specific retention (C)** = Volume retained per unit volume → **1**
- **Specific storage (D)** = Volume released from unit volume per unit head decline → **5**

Answer: **(a) A-2, B-4, C-1, D-5**

Q 20 IES 1998

Water present in an artesian aquifer is usually:

(A) At sub-atmospheric pressure

(B) At atmospheric pressure

(C) At 0.5× atmospheric pressure

(D) Above atmospheric pressure

✦ SOLUTION & ANSWER

Ans: (D) Above atmospheric pressure

In a **confined (artesian) aquifer**, water is under pressure greater than atmospheric due to the weight of overlying confining layers and the elevated recharge area.

When a well is drilled, water rises above the aquifer top (artesian condition). If piezometric head exceeds ground level, well flows freely at surface.

Q 21 IES 1998

An aquifer confined at top and bottom is stratified into three layers. [Figure not available in source]

Transmissivity of the aquifer system (m^2/day):

(A) 260	(B) 227
(C) 80	(D) 23

✦ SOLUTION & ANSWER

Ans: (A) 260 m^2/day

For a layered (stratified) confined aquifer:

$T = \Sigma(K_i \times b_i)$ — sum of (hydraulic conductivity × thickness) for each layer.

[Layer data not visible in source — official answer gives T = **260 m^2/day**].

Answer: **(A) 260 m^2/day**

Q 22 IES 1996

The yield of a well depends upon:

(A) Permeability of soil

(B) Area of aquifer opening into the wells

(C) Actual flow velocity

(D) All of the above

✦ SOLUTION & ANSWER

Ans: (D) All of the above

By **Darcy's Law**: $Q = K \times i \times A$

Yield depends on ALL three factors simultaneously:

- **Permeability (K)** — higher K → greater yield
- **Area of aquifer opening (A)** — larger area → greater yield
- **Flow velocity ($v = K \times i$)** — depends on hydraulic gradient

Answer: **(D) All of the above**

Q 23 IES 2011

Consider the following zones:

1. Saturation zone   2. Capillary zone   3. Intermediate zone   4. Soil water zone

Which of the above zones does NOT relate to the zone of aeration?

(a) 1 and 2

(b) 2 and 3

(c) 4 only

(d) 1 only

✦ SOLUTION & ANSWER

Ans: (d) 1 only

The **Zone of Aeration (Vadose Zone)** includes:

✓ Capillary zone (2) — just above water table

✓ Intermediate zone (3) — between root zone and capillary fringe

✓ Soil water/root zone (4) — near the surface

✗ **Saturation zone (1)** — is BELOW the water table and does NOT belong to the zone of aeration.

Answer: **(d) 1 only**

Q 24 IES 2014

Groundwater flows through an aquifer: area = 1.0×10^4 m^2, length = 1500 m. Piezometric heads = 300 m and 250 m at entry and exit. Discharge = 1500 m^3/day. Hydraulic conductivity is:

(a) 3.5 m/day

(b) 4.5 m/day

(c) 5.0 m/day

(d) 5.5 m/day

✦ SOLUTION & ANSWER

Ans: (b) 4.5 m/day

Hydraulic gradient: **$i = (300 - 250)/1500 = 50/1500 = 1/30$**

Using Darcy's Law: $Q = K \times i \times A$

$K = Q/(i \times A) = 1500 / ((1/30) \times 10^4) = 1500 \times 30 / 10000 =$ **4.5 m/day**

Answer: **(b) 4.5 m/day**

Q 25 IES 2014

An unconfined aquifer has: porosity = 35%, permeability = 40 m/day, specific yield = 0.15, area = 100 km². If water table falls by 0.2 m, the volume of water lost is:

(a) 1.5 Mm^3	(b) 3.0 Mm^3
(c) 7.0 Mm^3	(d) 8.0 Mm^3

✦ SOLUTION & ANSWER

Ans: (b) 3.0 Mm^3

Volume lost = S_y × Area × Drop

= 0.15 × 100×10^6 m^2 × 0.2 m

= **3.0×10^6 m^3 = 3.0 Mm^3**

(Note: Permeability and porosity are not needed for this calculation — only specific yield matters for water released from storage.)

Answer: **(b) 3.0 Mm^3**

Q 26 IES 2014

A tubewell has: diameter = 30 cm, strainer length = 15 m, drawdown = 3 m, sand effective size = 0.2 mm, K = 50 m/day, radius of drawdown = 150 m. Yield of the tubewell is:

(a) 240 L/s

(b) 120 L/s

(c) 24 L/s

(d) 12 L/s

✦ SOLUTION & ANSWER

Ans: (c) 24 L/s

Confined aquifer (Thiem's equation): $Q = 2\pi Kbs / \ln(R/r_w)$

$K = 50$ m/day $= 5.787\times10^{-4}$ m/s; $b = 15$ m; $s = 3$ m; $R = 150$ m; $r_w = 0.15$ m

$\ln(R/r_w) = \ln(150/0.15) = \ln(1000) = 6.908$

$Q = 2\pi \times 5.787\times10^{-4} \times 15 \times 3 / 6.908$

$= 2\pi \times 5.787\times10^{-4} \times 45 / 6.908 =$ **0.02367 m³/s ≈ 23.7 L/s ≈ 24 L/s**

Answer: **(c) 24 L/s**

Q 27 IES 2014

3.5 million m^3 of water is pumped from an unconfined aquifer having an area of 6.3 km^2. If the water table drops by 2.5 m, the specific yield of the aquifer is:

(a) 32%

(b) 28%

(c) 25%

(d) 22%

✦ SOLUTION & ANSWER

Ans: (d) 22%

S_y = Volume pumped / (Area × Drop)

= 3.5×10^6 / (6.3×10^6 × 2.5)

= 3.5 / 15.75 = **0.222 ≈ 22%**

Answer: **(d) 22%**

Q 28 IES 2019

The coefficient of transmissibility T for a confined aquifer determined by a pumping-out test. The applicable formula is: [Figure not available in source]

(A) Option A (B) Option B (C) Option C (D) Option D

✦ SOLUTION & ANSWER

Ans: (A)

The standard formula for transmissibility from a pumping test (Cooper-Jacob method) is:

$$T = 2.303 \times Q / (4\pi \times \Delta s)$$

where Δs = drawdown per log cycle on a semi-log plot of drawdown vs. time.

[Figure with formula options not available in source — official answer: **(A)**]

Q 29 IES 2018

Consider the following statements about waterlogging:
1. Waterlogging is the rise of the groundwater table leading to increased salinity reducing crop yield.
2. Waterlogging cannot be eliminated in certain areas but can be controlled if percolation is checked.
Which of the above statements are correct?

(a) 1 only

(b) 2 only

(c) Both 1 and 2

(d) Neither 1 nor 2

✦ SOLUTION & ANSWER

Ans: (c) Both 1 and 2

✓ **Statement 1** — Correctly defines waterlogging: rise of water table → reduces aeration → salt accumulation → decreased crop yield.
✓ **Statement 2** — In irrigated areas with poor drainage, waterlogging is difficult to eliminate entirely but CAN be controlled by checking excess percolation (lining canals, controlled irrigation).
Answer: **(c) Both**

Q 30 IES 2018

Groundwater flows through an aquifer: area = 1.0×10^4 m^2, length = 1500 m. Heads = 300 m and 250 m at entry and exit. Discharge = 750 m^3/day. Hydraulic conductivity is:

(a) 1.50 m/day

(b) 2.25 m/day

(c) 3.50 m/day

(d) 4.25 m/day

✦ **SOLUTION & ANSWER**

Ans: (b) 2.25 m/day

Hydraulic gradient: **$i = (300 - 250)/1500 = 1/30$**

$K = Q/(i \times A) = 750 / ((1/30) \times 10^4) = 750 \times 30 / 10000 =$ **2.25 m/day**

(Compare with Q24: same aquifer, double the discharge → double K)

Answer: **(b) 2.25 m/day**

Q 31 IES 2018

Effects of sustained excessive groundwater pumping include:

1. Drying of lakes and streams 2. Deterioration of groundwater quality

3. Land subsidence 4. Increased seismic activity 5. Increased cost of extraction

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

✦ SOLUTION & ANSWER

Ans: (b) 1, 2, 3 and 5

✓ **1** — Streams/lakes dry up as groundwater baseflow diminishes.

✓ **2** — Saltwater intrusion and contamination deteriorate quality.

✓ **3** — Compaction of aquifer matrix causes land subsidence.

✗ **4** — Seismic activity is associated with wastewater injection, NOT pumping.

✓ **5** — Deeper pumping levels increase energy and extraction costs.

Answer: **(b) 1, 2, 3 and 5**

Q 32 IES 2017

Consider the following statements about groundwater aquifers:

1. Specific storage = specific capacity per unit depth of aquifer.

2. Specific capacity = storage coefficient per unit aquifer depth.

3. Specific capacity is constant for a given well.

4. In 1D flow in a confined aquifer between two water bodies, piezometric head follows a straight line.

Which are correct?

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

✦ SOLUTION & ANSWER

Ans: (b) 2 and 4

✓ **Statement 2** — Specific capacity is related to transmissivity (T = K×b), and thus to storage coefficient per unit aquifer depth.

✓ **Statement 4** — For steady 1D flow, Darcy's law gives a linear (straight-line) piezometric head between the two boundaries.

✗ **Statement 1** — Specific storage ≠ specific capacity per unit depth (different definitions).

✗ **Statement 3** — Specific capacity varies with pumping rate due to well losses.

Answer: **(b) 2 and 4**

Q 33 IES 2017

An unconfined aquifer has: specific yield = 20%, specific retention = 15%, permeability = 35 m²/day. Consider:

1. Porosity of aquifer = 35%.

2. Transmissibility = 35 m²/day.

3. Volume of water lost per metre drop in water table per 100 km² of area = 20 million m³.

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

✦ SOLUTION & ANSWER

Ans: (a) 1 and 3

✓ **Statement 1**: Porosity = $S_y + S_r$ = 0.20 + 0.15 = **0.35 = 35%** ✓

✗ **Statement 2**: T = K×b; aquifer depth not given, so cannot confirm T = 35 m²/day.

✓ **Statement 3**: V = $S_y \times A \times \Delta h = 0.20 \times 100\times10^6 \times 1$ = **20×10^6 m³ = 20 Mm³** ✓

Answer: **(a) 1 and 3**

Q 34 IES 2016

Which of the following statements about aquifer characteristics are correct?

1. Storage coefficient = volume of water released from entire aquifer per unit depression of piezometric head.

2. Storage coefficient equals specific yield for a water table (unconfined) aquifer.

3. Both storage coefficient S and transmissivity T are dimensionless.

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

✦ SOLUTION & ANSWER

Ans: (b) 2 only

✗ **Statement 1** — Storage coefficient (S) = volume released per unit AREA of aquifer per unit head change, NOT from the entire aquifer.

✓ **Statement 2** — For an unconfined (water table) aquifer, $S = S_y$ (specific yield) since drainage is by gravity.

✗ **Statement 3** — S is dimensionless, BUT T has dimensions of $[L^2/T]$ (e.g., m^2/day).

Answer: **(b) 2 only**

Q 35 IES 2015

The dependable discharge of a lone circular open well in a semi-infinite aquifer is increased most easily by:

(A) Increasing the diameter

(B) Providing a square kerb

(C) Deepening the well

(D) Coarser screening filter

✦ SOLUTION & ANSWER

Ans: (C) Deepening the well

For an open well, yield depends on the wetted area of aquifer contact with the well.

Deepening the well significantly increases the wetted perimeter and the aquifer area exposed, leading to a proportional increase in yield.

Increasing diameter has only a logarithmic (weak) effect: $Q \propto 1/\ln(R/r_w)$.

Answer: **(C) Deepening the well**

Q 36 IES 2013

Continuous pumping is done for 7 hrs from a 25 ha catchment. Porosity = 30%, specific retention = 10%, water table drop = 1 m. The change in storage is:

(a) 7.5 ha-m

(b) 0.75 ha-m

(c) 1.87 ha-m

(d) 0.187 ha-m

✦ **SOLUTION & ANSWER**

Ans: (a) 7.5 ha-m

S_y = Porosity − Specific retention = 0.30 − 0.10 = 0.20

Change in storage = S_y × Area × Drop = 0.20 × 25 × 1 = **5.0 ha-m**

Note: Official answer key gives (a) 7.5 ha-m, which corresponds to using porosity directly: 0.30 × 25 × 1 = **7.5 ha-m** (if porosity is used as the storage parameter).

Answer: **(a) 7.5 ha-m** (as per official key)

Q 37 IES 2012

Statement I: When a tubewell penetrates a homogeneous aquifer and is pumped, lowering of the water surface occurs around the well — this is called the 'Drawdown curve'.

Statement II: Since the pressure on the drawdown curve is always atmospheric, it is called the drawdown curve.

(a) Both true; Statement II explains Statement I
(b) Both true; Statement II does not explain Statement I
(c) Statement I is true; Statement II is false
(d) Statement I is false; Statement II is true

✦ SOLUTION & ANSWER

Ans: (c)

✓ **Statement I — TRUE:** The cone of depression/drawdown curve correctly describes the lowering of the water surface during pumping.

✗ **Statement II — FALSE:** The term "drawdown" refers to the EXTENT of lowering of the water level, not because pressure is atmospheric. In a confined aquifer, the drawdown surface is the piezometric surface — NOT a free atmospheric surface.

Q 38 IES 2012

In a confined aquifer, two observation wells are 1500 m apart. Piezometric heads = 50 m and 25 m. K = 30 m/day, porosity = 0.25. Time of travel of an inert tracer between the two wells:

(a) 75 days

(b) 750 days

(c) 1200 days

(d) 3000 days

✦ SOLUTION & ANSWER

Ans: (b) 750 days

Hydraulic gradient: i = (50 − 25)/1500 = 25/1500 = **1/60**

Darcy velocity: v = K × i = 30 × (1/60) = **0.5 m/day**

Seepage (actual) velocity: V_s = v/n = 0.5/0.25 = **2.0 m/day**

Time = Distance/V_s = 1500/2.0 = **750 days**

Answer: **(b) 750 days**

Q 39 IES 2012

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

(a) Water table surface

(b) Capillary fringe

(c) Piezometric surface

(d) Physical top surface of aquifer

✦ SOLUTION & ANSWER

Ans: (c) Piezometric surface

The **piezometric (potentiometric) surface** is the imaginary surface connecting the water levels in piezometer tubes (observation wells) that penetrate a confined aquifer.

It represents the pressure head distribution in the confined aquifer.

Water table = free surface in unconfined aquifer; Piezometric surface = pressure surface in confined aquifer.

Q 40 IES 2012

What is the volume of water stored in a fully saturated soil column with porosity = 0.35, cross-sectional area = 1 m^2, depth = 3 m?

(a) 2.0 m^3	(b) 0.105 m^3
(c) 1.05 m^3	(d) 3.0 m^3

✦ SOLUTION & ANSWER

Ans: (c) 1.05 m^3

Volume of water = Porosity × Total volume

= 0.35 × (1 m^2 × 3 m)

= 0.35 × 3 = **1.05 m^3**

(In a fully saturated column, all void space is filled with water; void volume = $n \times V_{total}$)

Answer: **(c) 1.05 m^3**

Q 41 IES 2012

Statement I: Rainwater is collected in underground tanks for future use and for recharging the aquifer.

Statement II: Rainwater harvesting pits allow rainwater to percolate and recharge the aquifer.

(a) Both true; Statement II explains Statement I
(b) Both true; Statement II does not explain Statement I
(c) Statement I is true; Statement II is false
(d) Statement I is false; Statement II is true

✦ SOLUTION & ANSWER

Ans: (d)

✗ **Statement I — FALSE:** Underground storage tanks collect rainwater for DIRECT USE — they are closed/sealed systems and do NOT recharge the aquifer. Aquifer recharge requires water to reach the water table through the soil.
✓ **Statement II — TRUE:** Harvesting pits (open, unlined) allow rainwater to percolate through soil and directly recharge the aquifer.

Q 42 IES 2010

Assertion (A): A strainer well has a wire mesh around it.

Reason (R): The wire mesh prevents fine particles from entering the well.

(a) Both A and R are true and R explains A
(b) Both A and R are true but R does not explain A
(c) A is true but R is false
(d) A is false but R is true

✦ SOLUTION & ANSWER

Ans: (a) Both true, R explains A

✓ **Assertion A — TRUE:** A strainer well (slotted/perforated well) has a wire mesh/screen around the perforated pipe section.
✓ **Reason R — TRUE and Explains A:** The wire mesh is provided specifically to prevent fine sand and silt particles from entering the well casing while allowing water to flow in freely.
R is the correct explanation for A. Answer: **(a)**

Q 43 IES 2010

An unconfined aquifer has: porosity = 30%, permeability = 35 m/day, specific yield = 0.20, area = 100 km². If water table falls by 0.25 m, the volume of water lost (in Mm³) is:

(a) 2.0 Mm³	(b) 5.0 Mm³
(c) 1.0 Mm³	(d) 4.0 Mm³

✦ SOLUTION & ANSWER

Ans: (b) 5.0 Mm³

Volume lost = S_y × Area × Drop

= 0.20 × 100×10^6 m² × 0.25 m

= **5.0×10^6 m³ = 5.0 Mm³**

(Porosity and permeability not required for storage calculation)

Answer: **(b) 5.0 Mm³**

Q 44 IES 2009

A groundwater basin has: area = 10 km², maximum water table fluctuation = 1.5 m, specific yield = 10%. The available groundwater storage (in Mm³) is:

(a) 1.0 Mm³	(b) 1.5 Mm³
(c) 2.5 Mm³	(d) 2.0 Mm³

✦ SOLUTION & ANSWER

Ans: (b) 1.5 Mm³

Storage = S_y × Area × Fluctuation

= $0.10 \times 10\times10^6$ m² × 1.5 m

= **1.5×10^6 m³ = 1.5 Mm³**

Answer: **(b) 1.5 Mm³**

Q 45 IES 2007

How is the determination of storage coefficient (S) and transmissivity (T) done?

1. Recording drawdown in the pumped well at different time intervals.

2. Recording drawdown in observation wells at different time intervals.

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

✦ SOLUTION & ANSWER

Ans: (c) Both 1 and 2

✓ **Method 1** — Drawdown data from the pumped well itself can yield an approximate T (using well loss corrections).

✓ **Method 2** — Drawdown in observation wells at known distances and times is the preferred method (Theis/Cooper-Jacob) and yields more accurate values of both S and T.

Answer: **(c) Both**

Q 46 IES 2005

Discharge per unit drawdown at a well is known as:

(a) Specific yield

(b) Specific storage

(c) Specific retention

(d) Specific capacity

✦ SOLUTION & ANSWER

Ans: (d) Specific capacity

Specific capacity = Q / s_w = well discharge ÷ drawdown at the well [m^3/day per m].

- Specific yield = volume drained by gravity per unit volume of aquifer.
- Specific storage = volume released per unit volume per unit head decline.
- Specific retention = volume retained per unit volume after drainage.

Answer: **(d) Specific capacity**

Q 47 IES 2004

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

Reason (R): Yield is directly proportional to the area of the aquifer opening.

(a) Both A and R are true and R explains A
(b) Both A and R are true but R does not explain A
(c) A is true but R is false
(d) A is false but R is true

✦ SOLUTION & ANSWER

Ans: (d) A false, R true

✓ **Reason R — TRUE:** Yield ∝ Area of aquifer opening (by Darcy's Law: $Q = K \times i \times A$).

✗ **Assertion A — FALSE:** If yield were proportional to area: (75/50) = 1.5× increase → expected yield = 10 × 1.5 = 15 m^3/day. But A claims yield = 20 m^3/day — this does NOT satisfy proportionality. Assertion A is factually incorrect.

Answer: **(d) A false, R true**

Q 48 IES 2004

Which one of the following correctly defines aquiclude?

(a) A saturated formation that stores and yields water

(b) A formation where only seepage is possible, yielding insignificant quantity

(c) A formation that is not porous nor permeable

(d) A formation essentially impermeable to flow of water

✦ SOLUTION & ANSWER

Ans: (d)

Aquiclude = a geological formation that is essentially impermeable — it can store water but does NOT transmit it (e.g., clay).

• Option (a) = **Aquifer** — stores AND yields water.

• Option (b) = **Aquitard** — semi-permeable, insignificant yield.

• Option (c) = **Aquifuge** — neither porous nor permeable.

Answer: **(d)**

Q 49 IES 2003

Match List-I with List-II:
List-I: A. Pumping Test   B. Recuperation   C. Pressure Test   D. Jar Test
List-II: 1. Rise of water level observed over time   2. Pumping adjusted to maintain constant water level   3. Vigorous mixing of chemical in a jar   4. Pipeline filled with water, allowed to stand, then double pressure applied

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

✦ SOLUTION & ANSWER

Ans: (b) A-2, B-1, C-4, D-3

- **Pumping Test (A)** → Pumping rate adjusted to maintain constant water level → **2**
- **Recuperation (B)** → Water rises after pump stops; rise monitored over time → **1**
- **Pressure Test (C)** → Pipeline filled, tested at double working pressure → **4**
- **Jar Test (D)** → Vigorous chemical mixing in a jar (water quality test) → **3**

Answer: **(b)**

Q 50 IES 2003

Which of the following statements about well development are correct?

1. Involves reversal of flow through the screen.

2. Increases permeability in the area toward the well.

3. Decreases permeability in the area toward the well.

4. Continued till sand and silt free water is pumped.

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

✦ SOLUTION & ANSWER

Ans: (b) 1, 2 and 4

✓ **1** — Surging/reversal of flow through screen to loosen fine material.

✓ **2** — Removing fine particles INCREASES permeability near the well (gravel pack effect).

✗ **3** — FALSE; well development INCREASES, not decreases permeability.

✓ **4** — Development continues until clear, sand/silt-free water is pumped.

Answer: **(b) 1, 2 and 4**

Q 51 IES 2003

Match List-I with List-II:

List-I: A. Specific yield B. Safe yield C. Specific capacity D. Field capacity

List-II: 1. Discharge per unit drawdown 2. Same as specific retention 3. Water that can be removed by pumping 4. Limit of withdrawal without depletion 5. Water-bearing capacity

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

✦ SOLUTION & ANSWER

Ans: (b) A-3, B-4, C-1, D-2

- **Specific yield (A)** = Water removable by pumping (gravity drainage) → **3**
- **Safe yield (B)** = Maximum withdrawal without long-term depletion → **4**
- **Specific capacity (C)** = Discharge per unit drawdown → **1**
- **Field capacity (D)** = Same as specific retention (water held against gravity) → **2**

Answer: **(b)**

Q 52 IES 2002

Match List-I with List-II:

List-I: A. Thiem's equation   B. Dupuit's assumption   C. Bernoulli's equation   D. Continuity equation

List-II: 1. Energy conservation   2. Mass conservation   3. Steady flow to a well in a confined aquifer   4. Steady flow in an unconfined aquifer

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

✦ SOLUTION & ANSWER

Ans: (d) A-3, B-4, C-1, D-2

- **Thiem's equation (A)** = Steady radial flow to a well in a confined aquifer → **3**
- **Dupuit's assumption (B)** = Flow is essentially horizontal in unconfined aquifer → **4**
- **Bernoulli's equation (C)** = Energy conservation along a streamline → **1**
- **Continuity equation (D)** = Conservation of mass (mass balance) → **2**

Answer: **(d)**

Q 53 IES 2002

The performance of a well is measured by its:

(a) Specific capacity	(b) Specific yield
(c) Storage coefficient	(d) Permeability coefficient

✦ SOLUTION & ANSWER

Ans: (a) Specific capacity

Specific capacity (Q/s_w) is the standard measure of well performance — it indicates how much water a well produces per unit of drawdown.

A higher specific capacity indicates a better-performing well (more productive for less drawdown).

It accounts for both aquifer properties (T) and well efficiency.

Answer: **(a) Specific capacity**

Q 54 IES 2001

Assertion (A): The available yield of a tubewell can be doubled by doubling its diameter.

Reason (R): Yield varies inversely with the logarithm of the reciprocal of the diameter.

(a) Both A and R are true and R explains A
(b) Both A and R are true but R does not explain A
(c) A is true but R is false
(d) A is false but R is true

✦ SOLUTION & ANSWER

Ans: (d) A false, R true

✓ **Reason R — TRUE:** $Q \propto 1/\ln(R/r_w)$; yield increases logarithmically with diameter. Doubling diameter: ln(R/r) → ln(R/2r) — the change is very small.
✗ **Assertion A — FALSE:** Due to the logarithmic relationship, doubling the diameter does NOT double the yield. Example: R=300m, r=0.15m → ln(2000)=7.60; r=0.30m → ln(1000)=6.91 — only ~10% increase, not 100%.
Answer: **(d) A false, R true**

Q 55 IES 2000

The specific capacity of a well is the:

(a) Volume of water extracted by gravity per unit volume

(b) Discharge per unit drawdown

(c) Drawdown per unit discharge

(d) Rate of flow per unit width per entire thickness of aquifer

✦ SOLUTION & ANSWER

Ans: (b) Discharge per unit drawdown

Specific capacity = Q / s_w = discharge ÷ drawdown at the well [m^3/day/m or L/s/m].

• Option (a) = Specific yield.

• Option (c) = Inverse of specific capacity (hydraulic resistance).

• Option (d) = Transmissivity ($T = K \times b$ = Q per unit width per unit gradient).

Answer: **(b) Discharge per unit drawdown**