FEExamClick

# Free FE Civil Practice Exam

20 exam-style questions across the NCEES FE Civil knowledge areas, with an answer key and a worked solution for every question.

| 20 | 48 min | 110 |
|---|---|---|
| questions | suggested time | questions on the real exam |

## How to take it

1. Set a timer for 48 minutes, about 2.4 minutes a question. The real exam gives 5 h 20 min for 110 questions, about 2.9.
2. Use only the NCEES FE Reference Handbook (free from your MyNCEES account) and an NCEES-approved calculator.
3. Answer every question: the real exam has no penalty for wrong answers.
4. Check your answers with the key after question 20, then read every worked solution, including the ones you got right.

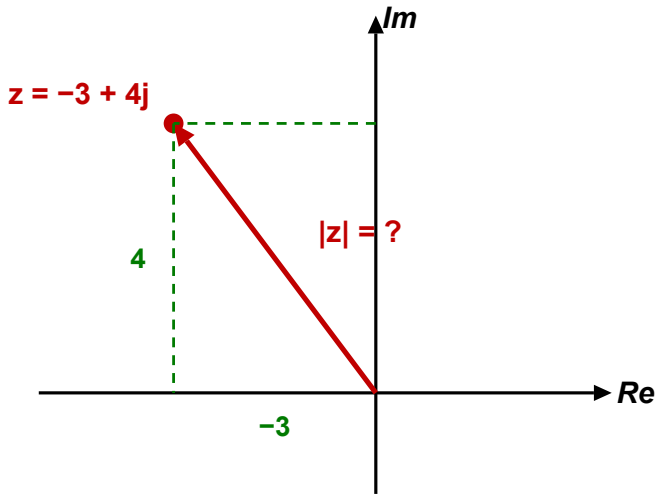
## The real exam is on a computer

The FE is computer-based, with the Handbook on screen. To practise the same 20 questions in that interface, with a countdown and your score by topic, take the free online version at feexamclick.com/fe-civil-practice-exam.

Original questions written to the NCEES FE Civil exam specification; NCEES does not publish its exam questions. © 2026 FEExamClick, feexamclick.com.

**Question 1** Mathematics and Statistics

What is the magnitude of the complex number $-3 + 4j$?




**A** 3

**B** 4

**C** 5

**D** 7

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**Question 2** Mathematics and Statistics

$X$ is normally distributed with mean 50 and standard deviation 8. What is $P(X > 62)$?

**A** 0.067

**B** 0.101

**C** 0.133

**D** 0.934

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## Question 3 Ethics and Professional Practice

A licensee is considering partnering with a firm known to submit fraudulent inspection certificates. What does the code require?

**A** Partnering is acceptable if you supervise their work

**B** Do not partner, practice, or offer to practice with a firm engaged in fraudulent practices

**C** Partner only if the firm is insured

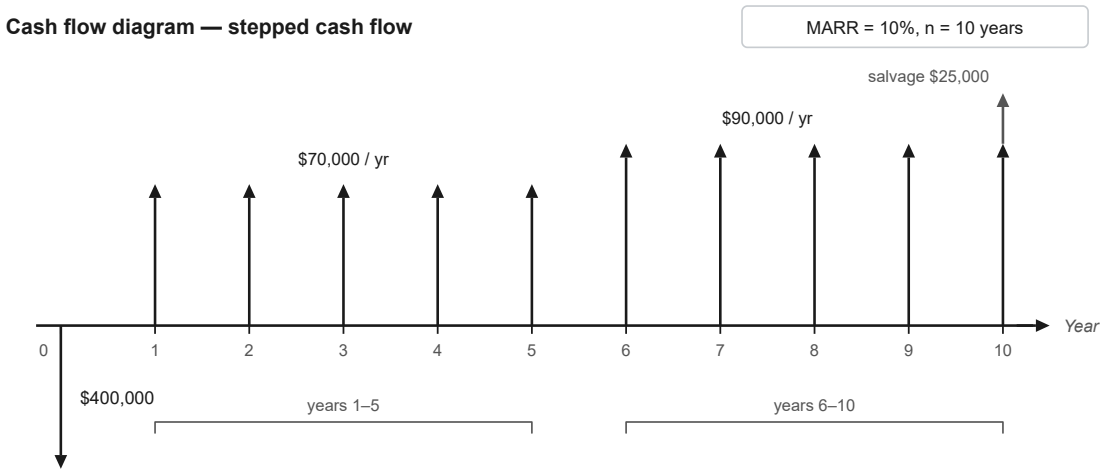
**D** Report is optional, so partnership is fine

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## Question 4 Engineering Economics

A water reuse system costs $\$400{,}000$ and generates the following net cash flows, shown in the figure:
- Years 1-5: $\$70{,}000$/year
- Years 6-10: $\$90{,}000$/year

If the MARR is 10% and the salvage value at year 10 is $\$25{,}000$, what is the net present worth of this investment?




Salvage arrives at year 10 on top of that year's cash flow. Inflows and outflows use separate vertical scales.

**A** $\$101{,}206$

**B** $\$216{,}166$

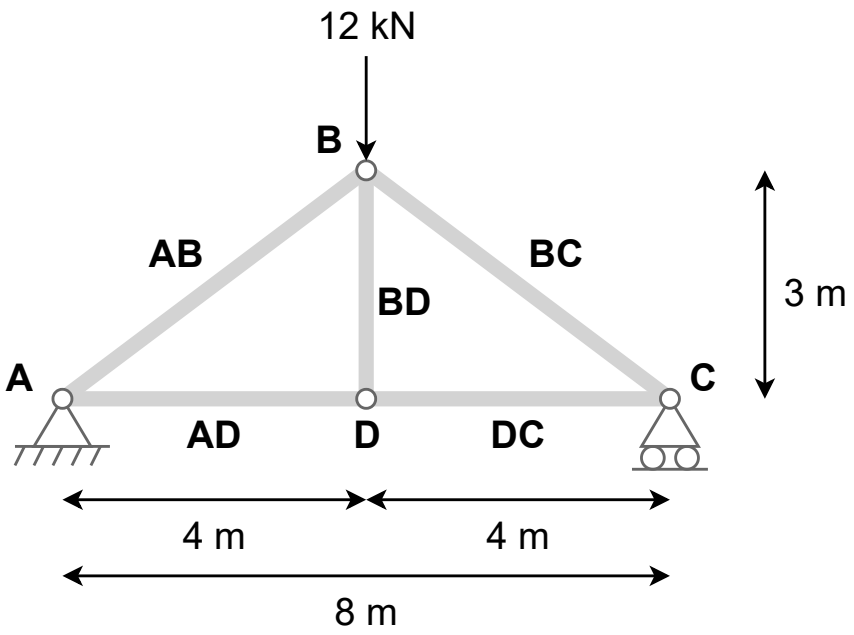
**C** $\$86{,}836$

**D** $\$77{,}198$

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**Question 5** Statics

Warren-type truss with joints $A(0,\,0)$ (pin), $D(4,\,0)$, $C(8,\,0)$ (roller), and $B(4,\,3)$. Members: AB, BC, AD, DC, BD. A $12\,\mathrm{kN}$ downward load is applied at joint B. What is the force in vertical member BD?




**A** 0 kN

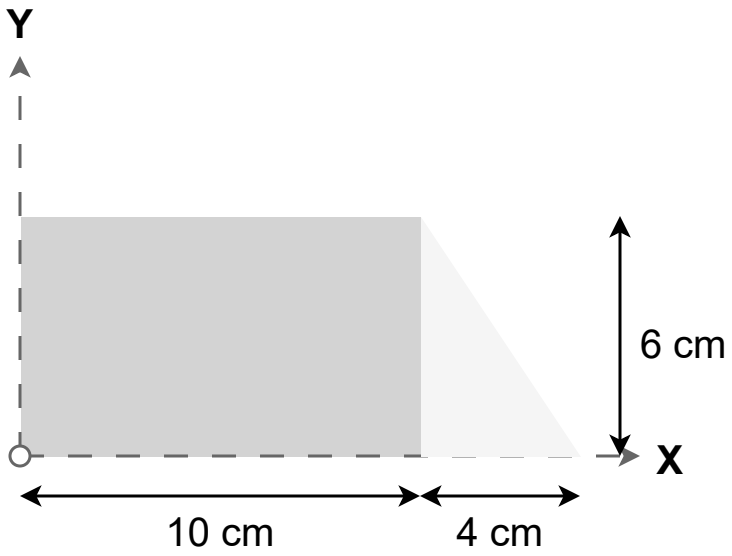
**B** 4.5 kN (tension)

**C** 6.0 kN (compression)

**D** 7.5 kN (tension)

### Question 6 Statics

Composite area (draw as a trapezoid): Start with a rectangle $10\,\text{cm}$ wide by $6\,\text{cm}$ tall with origin at $(0,\,0)$. Attach a right triangle on the right side such that the right angle is at $(10,\,0)$, the triangle extends $4\,\text{cm}$ to the right (to $x = 14$) and $6\,\text{cm}$ up (to $y = 6$). Find centroid $(\bar{x},\,\bar{y})$ of the combined area.




**A** (6.06, 2.83)

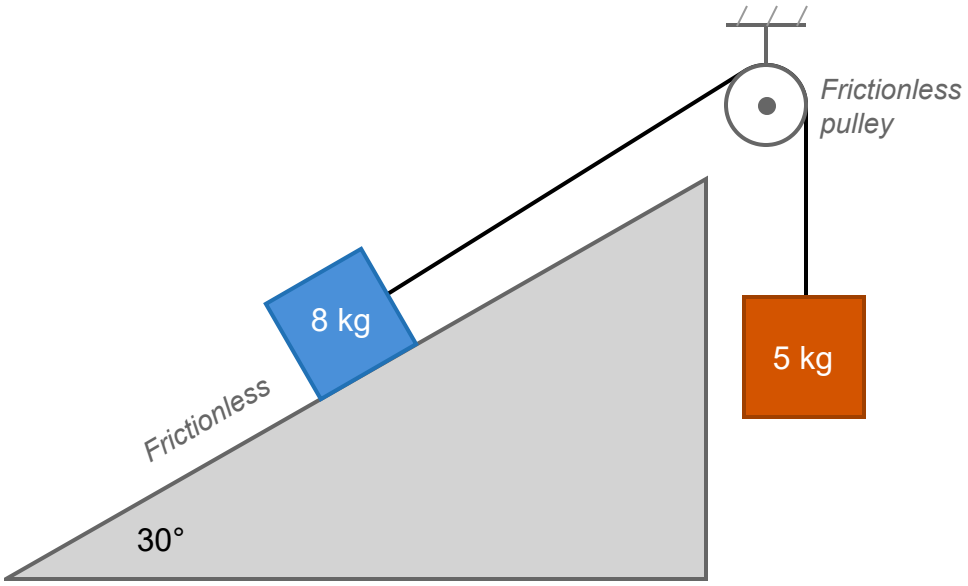
**B** (7.00, 3.00)

**C** (8.00, 2.50)

**D** (5.50, 3.50)

**Question 7** Dynamics

An $8\,\mathrm{kg}$ block on a frictionless $30^\circ$ incline is connected over a frictionless pulley to a $5\,\mathrm{kg}$ hanging mass. What is the acceleration magnitude of the system $(\mathrm{m/s^2})$?




**A** 0.75

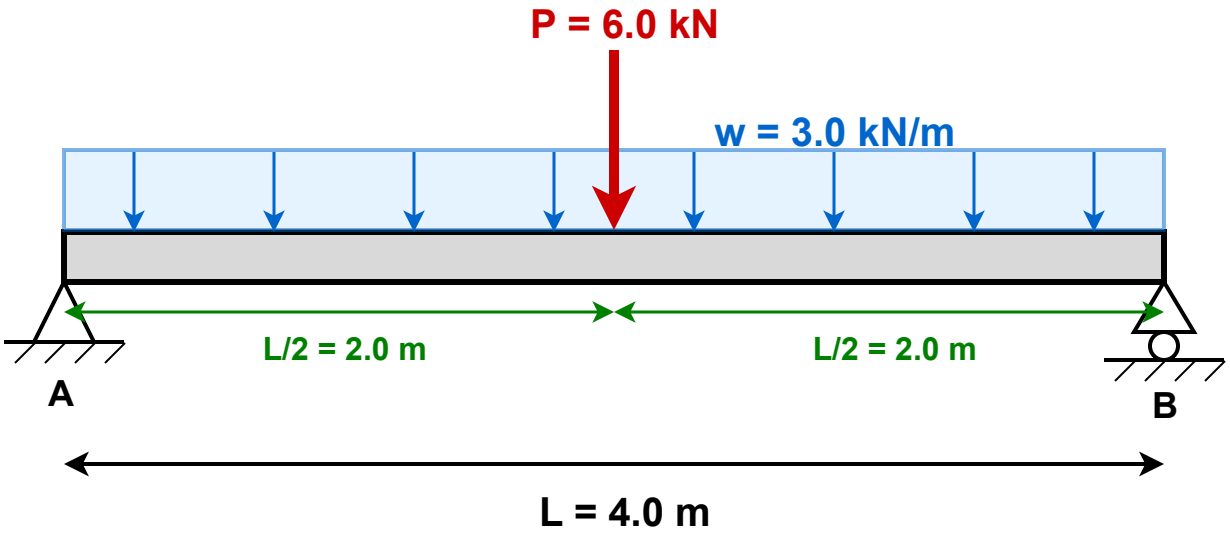
**B** 1.5

**C** 2.3

**D** 3.1

**Question 8** Mechanics of Materials

A simply supported beam has $L = 4.0\,\text{m}$ with a uniform load $w = 3.0\,\text{kN/m}$ over the span and an additional centered point load $P = 6.0\,\text{kN}$. What is the maximum bending moment (kN·m)?




**A** 6

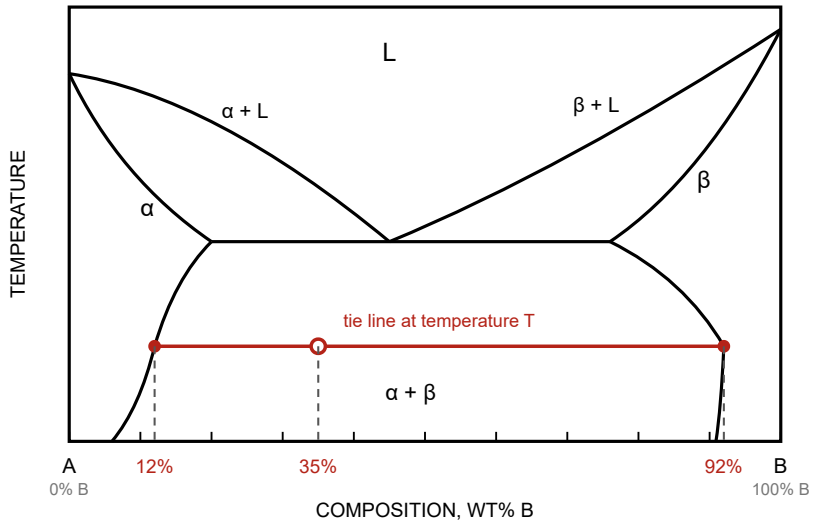
**B** 9

**C** 12

**D** 15

## Question 9 Materials

An alloy of average composition $35\,\mathrm{wt\%\ B}$ lies in the $\alpha + \beta$ field at temperature $T$. At that temperature the tie line meets the $\alpha$ boundary at $12\,\mathrm{wt\%\ B}$ and the $\beta$ boundary at $92\,\mathrm{wt\%\ B}$. The weight percent of the $\alpha$ phase is most nearly:




**A** 12%

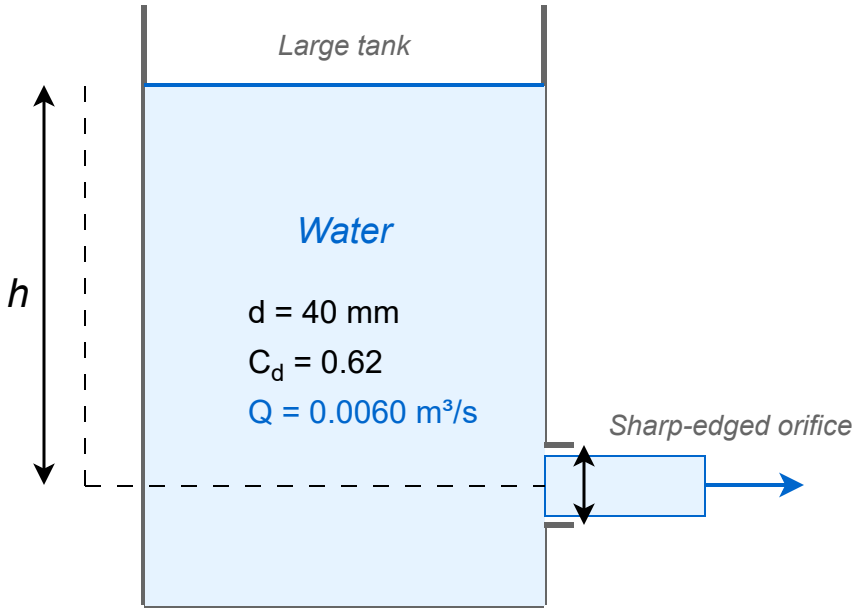
**B** 29%

**C** 38%

**D** 71%

**Question 10** Fluid Mechanics

What head $h$ is required for a $40\,\text{mm}$ sharp-edged orifice ($C_d = 0.62$) to discharge $Q = 0.0060\,\text{m}^3/\text{s}$ of water from a large tank?




**A** 1.2 m

**B** 1.7 m

**C** 2.0 m

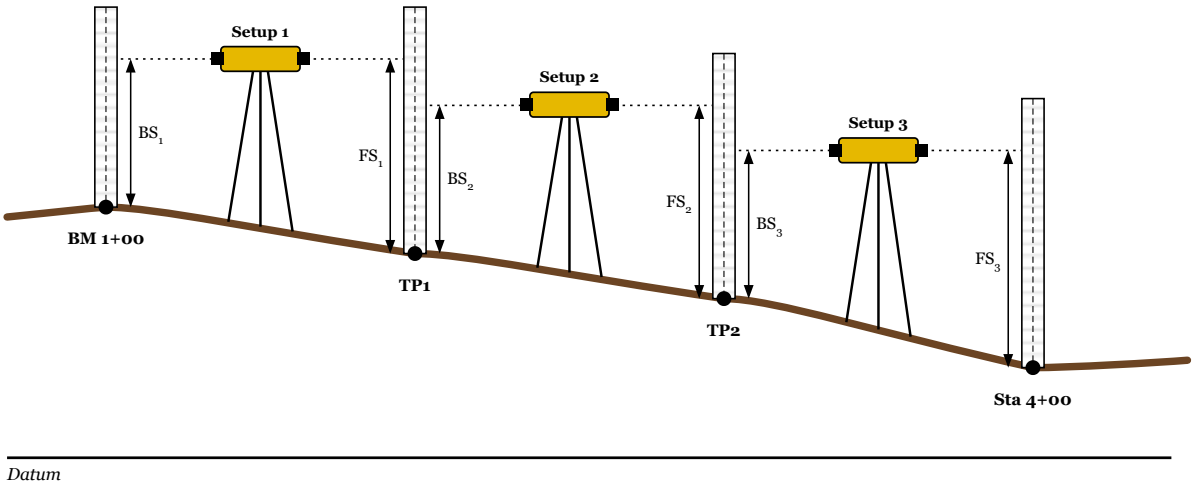
**D** 3.0 m

### Question 11 Surveying

Differential leveling runs from benchmark **Station 1+00** (elevation $725.00\,\text{ft}$) through two turning points to **Station 4+00**. The field notes are:

| Station | BS (ft) | FS (ft) |
|---|---|---|
| BM 1+00 | 4.18 | - |
| TP1 | 5.63 | 6.72 |
| TP2 | 3.47 | 8.10 |
| Sta 4+00 | - | 7.25 |

Using $HI = \text{Elev} + BS$ and $\text{Elev} = HI - FS$, what is the elevation of **Station 4+00** (nearest $0.01\,\text{ft}$)?




**A** $702.93\,\text{ft}$

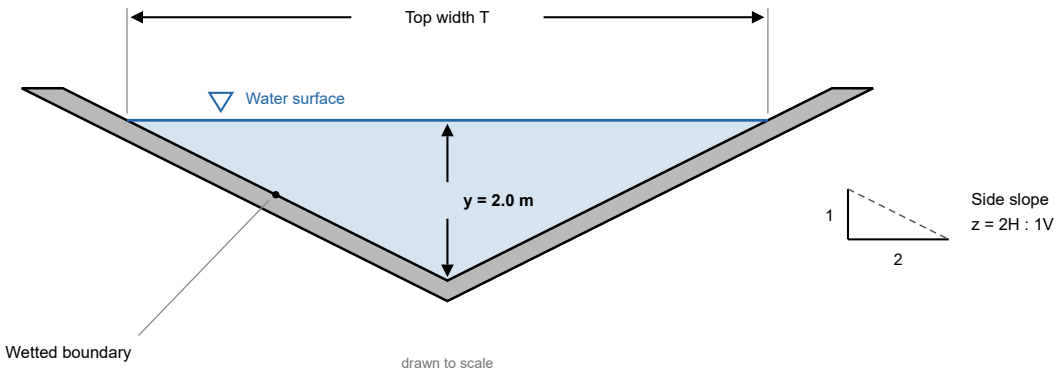
**B** $716.21\,\text{ft}$

**C** $733.79\,\text{ft}$

**D** $738.28\,\text{ft}$

## Question 12 Water Resources and Environmental Engineering

A triangular open channel has depth $y = 2.0\,\text{m}$ and side slopes $z = 2H : 1V$. What is the hydraulic radius $R_h$?




**A** $0.45\,\text{m}$

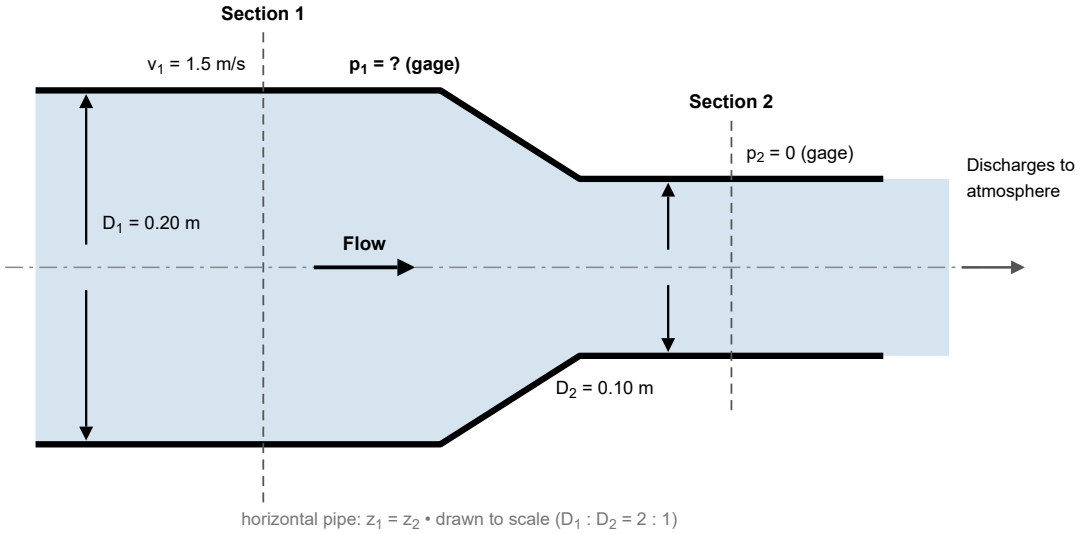
**B** $0.67\,\text{m}$

**C** $0.90\,\text{m}$

**D** $1.80\,\text{m}$

## Question 13 Water Resources and Environmental Engineering

Water flows in a horizontal pipe from $D_1 = 0.20\,\text{m}$ at section 1 to $D_2 = 0.10\,\text{m}$ at section 2. At section 1, $v_1 = 1.5\,\text{m/s}$. At section 2, water discharges to atmosphere ($p_2 = 0$ gage). Neglect losses. What is $p_1$ (gage)?




**A** $3.4\,\text{kPa}$

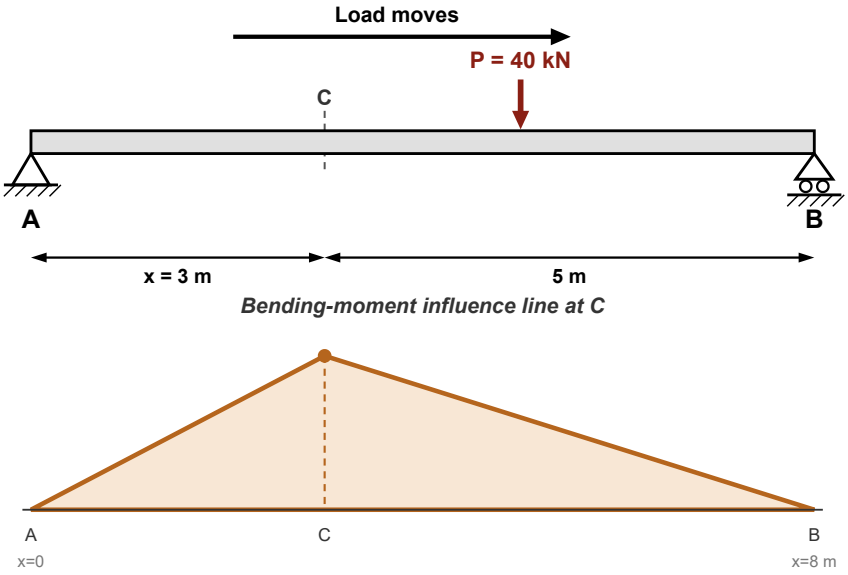
**B** $4.2\,\text{kPa}$

**C** $8.0\,\text{kPa}$

**D** $16.9\,\text{kPa}$

## Question 14 Structural Engineering

A simply supported beam $AB$ has $L = 8\,\text{m}$. Consider the influence line for BENDING MOMENT at section $C$ located $x = 3\,\text{m}$ from $A$. A moving point load $P = 40\,\text{kN}$ crosses the span. What is the maximum bending moment at $C$?




**A** $45\,\text{kN}\cdot\text{m}$

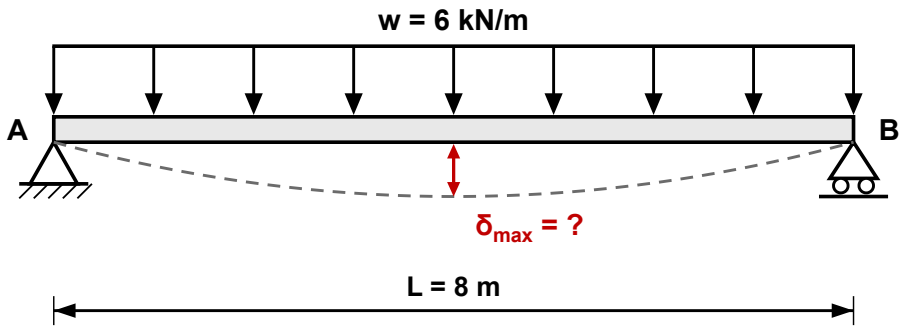
**B** $60\,\text{kN}\cdot\text{m}$

**C** $75\,\text{kN}\cdot\text{m}$

**D** $120\,\text{kN}\cdot\text{m}$

### Question 15 Structural Engineering

A simply supported beam of span $L = 8\,\text{m}$ carries a uniform load $w = 6\,\text{kN/m}$ over its full length. $E = 200\,\text{GPa}$ and $I = 5.0 \times 10^{-5}\,\text{m}^4$. What is the maximum deflection?




**A** $6.4\,\text{mm}$

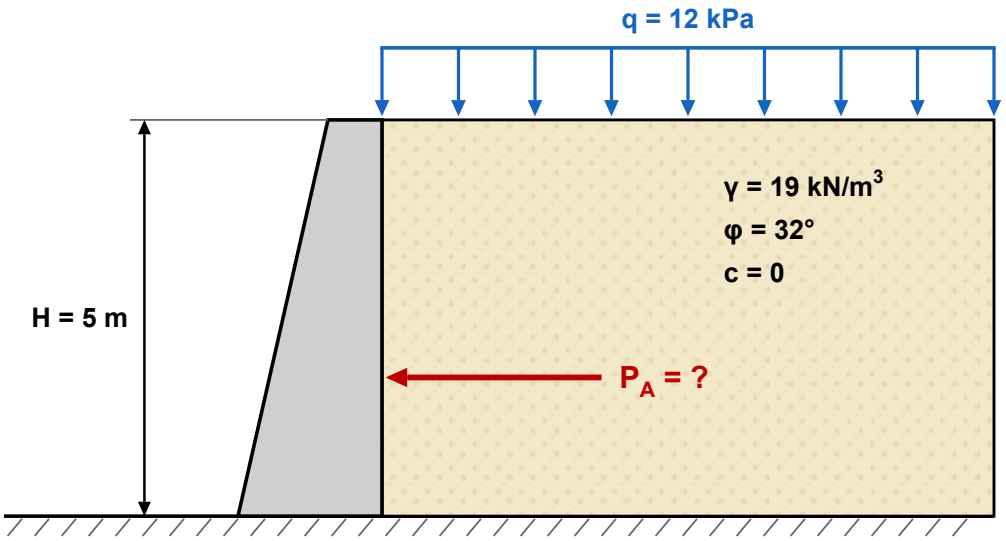
**B** $16\,\text{mm}$

**C** $32\,\text{mm}$

**D** $51\,\text{mm}$

**Question 16** Geotechnical Engineering

A smooth vertical wall retains $H = 5\,\text{m}$ of level granular backfill with $\gamma = 19\,\text{kN/m}^3$, $\phi = 32°$ and $c = 0$. A uniform surcharge $q = 12\,\text{kPa}$ acts over the whole backfill surface, and the water table is below the base of the wall. Using Rankine active pressure, what is the total active thrust $P_A$ on the wall, in $\text{kN}$ per meter of wall?




**A** $73\,\text{kN/m}$

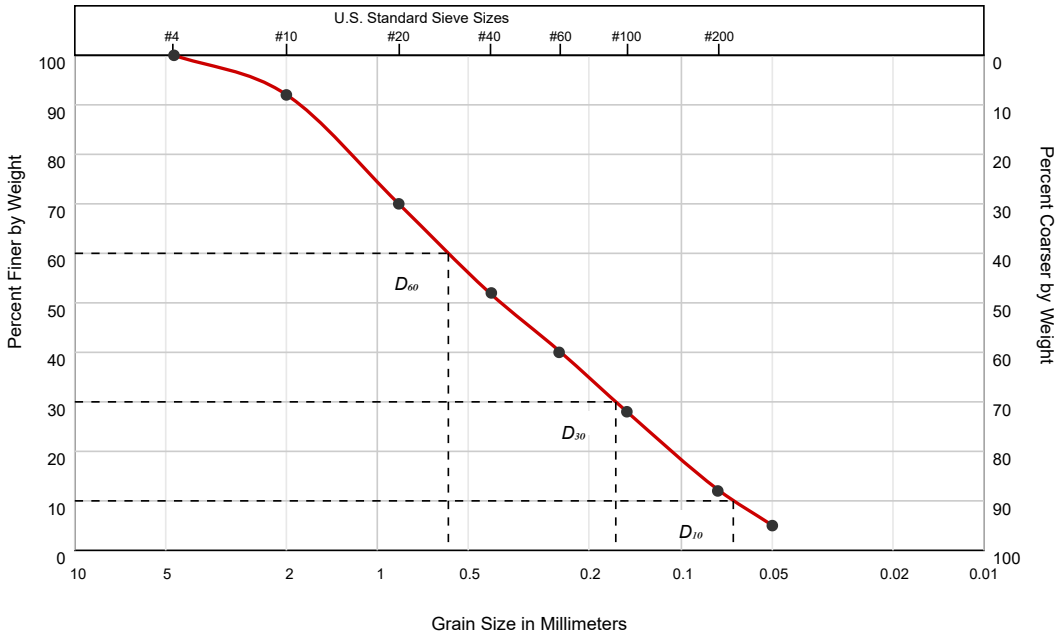
**B** $82\,\text{kN/m}$

**C** $91\,\text{kN/m}$

**D** $133\,\text{kN/m}$

## Question 17 Geotechnical Engineering

Sieve results (percent passing): 4.75mm 100, 2.0mm 92, 0.85mm 70, 0.425mm 52, 0.25mm 40, 0.15mm 28, 0.075mm 12, 0.05mm 5. From the semi-log grain-size curve, estimate $D_{10}$, $D_{30}$, $D_{60}$ (log interpolation) and compute $C_u$ and $C_c$. Which pair is closest?




**A** $C_u = 8.7$ and $C_c = 0.69$

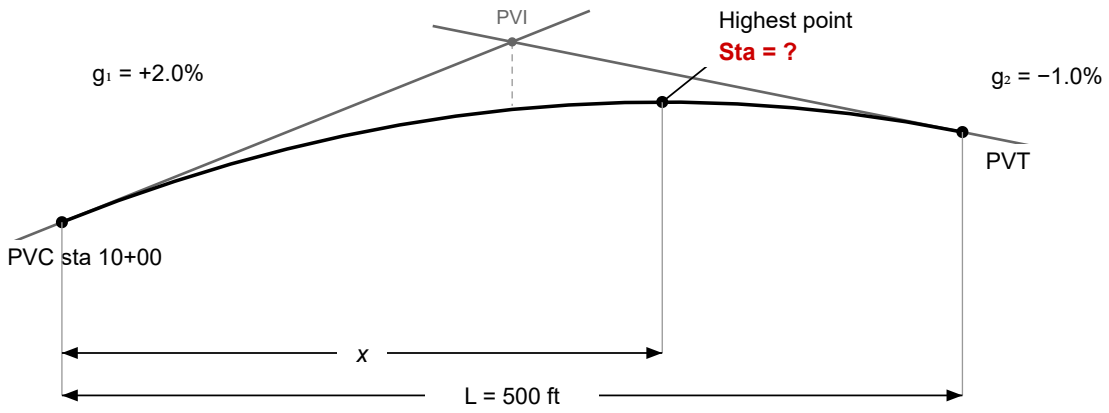
**B** $C_u = 8.7$ and $C_c = 1.6$

**C** $C_u = 10$ and $C_c = 1.0$

**D** $C_u = 12$ and $C_c = 0.30$

## Question 18 Transportation Engineering

A crest vertical curve has length $L = 500\,\text{ft}$ connecting $g_1 = +2.0\%$ to $g_2 = -1.0\%$. The $PVC$ is at $\text{sta}\ 10 + 00$. At what station is the highest point (nearest $1\,\text{ft}$)?




**A** $\text{sta}\ 12 + 50$

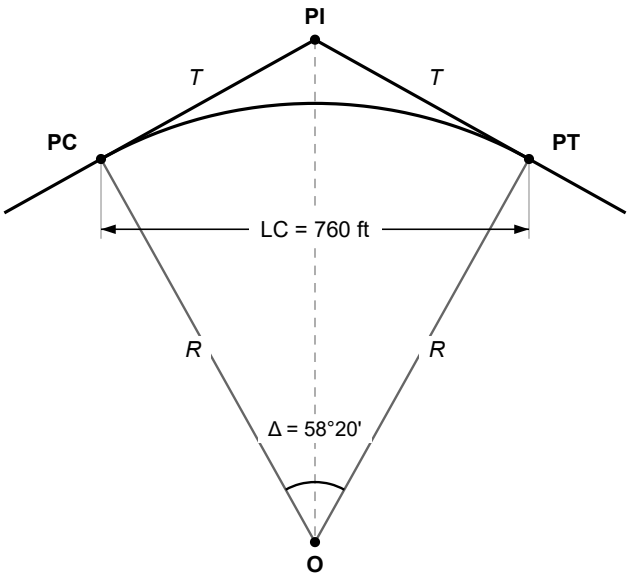
**B** $\text{sta}\ 13 + 33$

**C** $\text{sta}\ 14 + 10$

**D** $\text{sta}\ 11 + 67$

## Question 19 Transportation Engineering

A simple circular horizontal curve has intersection angle $\Delta = 58^\circ 20'$ and long chord $LC = 760\,\text{ft}$. What is the curve radius $R$ (ft), nearest $10\,\text{ft}$?




**A** $450\,\text{ft}$

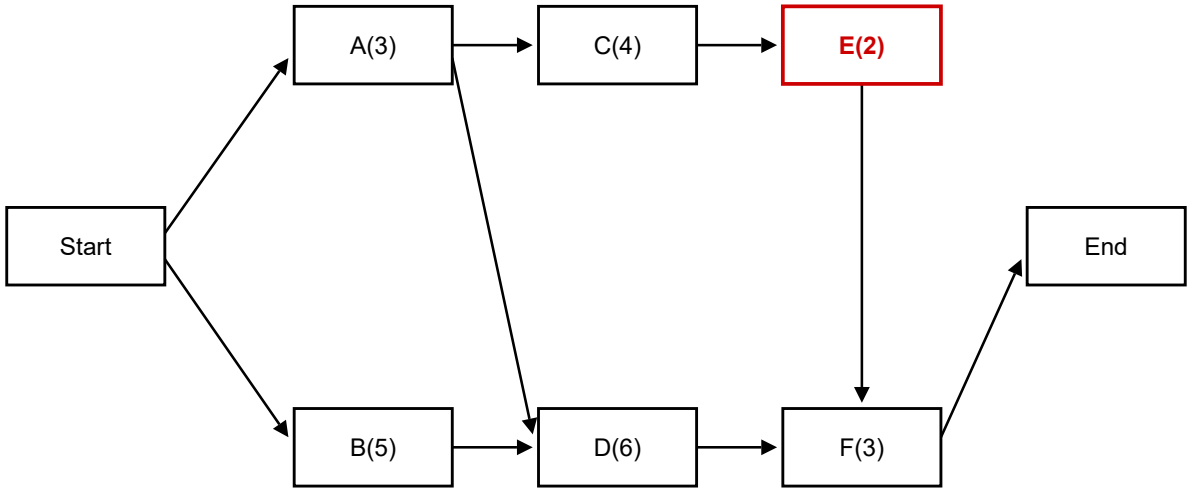
**B** $730\,\text{ft}$

**C** $760\,\text{ft}$

**D** $780\,\text{ft}$

## Question 20 Construction Engineering

An AON network is: A(3) start; B(5) start; C(4) after A; D(6) after A and B; E(2) after C; F(3) after D and E. What is the total float of activity E (days)?




**A** 2

**B** 4

**C** 5

**D** 6

# Answer key

| Question | Answer | NCEES knowledge area |
|---|---|---|
| 1 | **C** | Mathematics and Statistics |
| 2 | **A** | Mathematics and Statistics |
| 3 | **B** | Ethics and Professional Practice |
| 4 | **C** | Engineering Economics |
| 5 | **A** | Statics |
| 6 | **A** | Statics |
| 7 | **A** | Dynamics |
| 8 | **C** | Mechanics of Materials |
| 9 | **D** | Materials |
| 10 | **D** | Fluid Mechanics |
| 11 | **B** | Surveying |
| 12 | **C** | Water Resources and Environmental Engineering |
| 13 | **D** | Water Resources and Environmental Engineering |
| 14 | **C** | Structural Engineering |
| 15 | **C** | Structural Engineering |
| 16 | **C** | Geotechnical Engineering |
| 17 | **A** | Geotechnical Engineering |
| 18 | **B** | Transportation Engineering |
| 19 | **D** | Transportation Engineering |
| 20 | **A** | Construction Engineering |

Worked solutions start on the next page.

# Worked solutions

### Question 1 · Answer C

**Step 1** – Identify given complex number: $z = -3 + 4j$, so $a = -3$, $b = 4$.

**Step 2** – Recall from the FE Handbook: The magnitude (modulus) of a complex number $z = a + bj$ is:

$$|z| = \sqrt{a^2 + b^2}$$

This is the distance from the origin to the point $(a, b)$ in the complex plane — the same as the Pythagorean theorem.

**Step 3** – Substitute and compute:

$$|-3 + 4j| = \sqrt{(-3)^2 + (4)^2} = \sqrt{9 + 16} = \sqrt{25} = 5$$

**Step 4** – Common mistake: using $a = -3$ without squaring, giving $-9 + 16 = 7$. Always square before adding. The 3-4-5 right triangle is a classic result.

Option (A) is what you get by keeping only the real coefficient under the radical, $\sqrt{9} = 3$ - the mirror image of option (B), which keeps only the imaginary part.

**Correct answer: (C)**

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### Question 2 · Answer A

#### Step 1: Identify given information

| Item | Value |
|---|---|
| Distribution | Normal |
| Mean ($\mu$) | 50 |
| Standard deviation ($\sigma$) | 8 |
| Find | $P(X > 62)$ |

#### Step 2: Recall the standardization formula from the FE Handbook

Convert $X$ to a standard normal variable $Z \sim N(0, 1)$:

$$z = \frac{x - \mu}{\sigma}$$

Then use the standard normal table: $P(X > x) = 1 - \Phi(z)$, where $\Phi(z)$ is the CDF.

#### Step 3: Compute the z-score

$$z = \frac{62 - 50}{8} = \frac{12}{8} = 1.50$$

**Step 4: Look up the probability**

From the standard normal table: $\Phi(1.50) = 0.9332$

$$P(X > 62) = P(Z > 1.5) = 1 - 0.9332 = 0.0668 \approx 0.067$$

Educational note: $z = 1.5$ means 62 is 1.5 standard deviations above the mean. Only about 6.7% of observations fall above this value. The region $z > 1.96$ contains only 2.5%, so 1.5 is not an extreme value.

**Correct answer: (A)**

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**Question 3 · Answer B**

**Step 1 – Identify the ethical issue:** A licensee is considering a business partnership with a firm known to submit fraudulent inspection certificates. This tests the prohibition on associating with dishonest practices.

**Step 2 – Relevant rule:** NCEES Model Rules §240.15(A)(7): *"Licensees shall not knowingly associate with or allow the use of their name or firm name in a business venture by any person or firm which they know, or have reason to believe, engages in business or professional practices of a fraudulent or dishonest nature."*

**Step 3 – Apply the rule:** The firm is *known* to submit fraudulent certificates — this is not a suspicion. The licensee has explicit knowledge of dishonest practices, which means any partnership is strictly prohibited. Allowing your name to be associated with such a firm taints the integrity of the profession and violates the rule regardless of your personal supervision.

**Step 4 – Why other options are wrong:**
(A) Personal supervision of the firm does not override the rule — the prohibition is on knowingly associating with a fraudulent firm, period.
(C) Whether the firm is insured is irrelevant to the ethical prohibition against associating with fraudulent practices.
(D) Reporting is required, but it also does not make the partnership acceptable; the two obligations are separate and both apply.

**Correct answer: (B)**

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**Question 4 · Answer C**

**Handbook:** FE Reference Handbook 10.6, Engineering Economics — the (P/A) and (P/F) factors on p. 235, and the **i = 10.00% table on p. 241** (PDF viewer: page 247), which supplies every factor needed:

$$(P/A, 10\%, 5) = 3.7908, \quad (P/A, 10\%, 10) = 6.1446, \quad (P/F, 10\%, 10) = 0.3855$$

**Step 1 – Years 1–5.** A plain five-year annuity valued at year 0:

$$70{,}000(3.7908) = \$265{,}356$$

**Step 2 – Years 6–10. This is the step that decides the problem.** Those five payments do not start at year 1, so $(P/A, 10\%, 5)$ alone will not value them at year 0. Two equivalent ways to handle it:

*Subtract the factors:*

$$90{,}000\,[(P/A, 10\%, 10) - (P/A, 10\%, 5)] = 90{,}000(6.1446 - 3.7908) = 90{,}000(2.3538) = \$211{,}842$$

*Or shift back five years:* $(P/A, 10\%, 5) \times (P/F, 10\%, 5) = 3.7908(0.6209) = 2.3538$ — the same number. Use whichever you trust more; getting the same 2.3538 both ways is a good check.

**Step 3 – Salvage at year 10.**

$$25{,}000(0.3855) = \$9{,}638$$

**Step 4 – Add it all up.**

$$NPW = -400{,}000 + 265{,}356 + 211{,}842 + 9{,}638 = \mathbf{\$86{,}836}$$

**Step 5 – Answer: (C)**.

The NPW is positive, so the water reuse system clears the 10% MARR — but only by about $\$87{,}000$ on a $\$400{,}000$ investment, so the margin is thin.

**Step 6 – Eliminate the distractors:**

(B) $\$216{,}166$ values the second block with $(P/A, 10\%, 5)$ as though it began at year 1. That moves five years of $\$90{,}000$ half a decade closer to the present and inflates the answer by roughly $\$129{,}000$. This is the single most common error on a stepped series, and the reason the figure draws the two blocks separately.

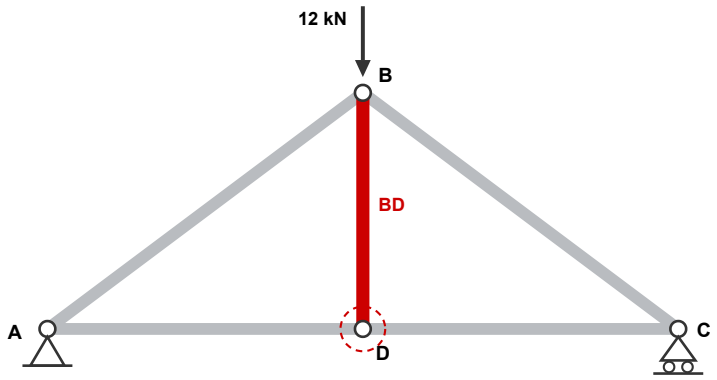
(A) $\$101{,}206$ averages the two blocks to $\$80{,}000$ per year and applies $(P/A, 10\%, 10)$. The average revenue is right, but averaging shifts money from the late years to the early ones where it is discounted less, so it overstates the result.

(D) $\$77{,}198$ is the correct calculation with the salvage value left out. It is the closest wrong answer, and it is only $\$9{,}638$ away — check that you used every arrow in the diagram, including the short one stacked at year 10.

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### Question 5 · Answer A

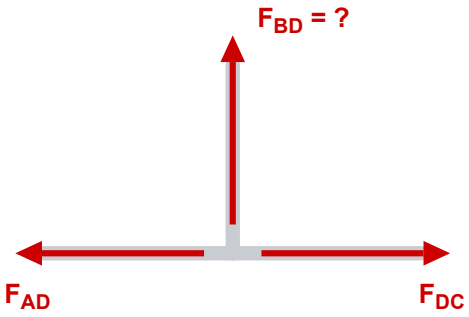
**Step 1 – Identify given information:** Warren-type truss with $12\,\mathrm{kN}$ load at B. At joint D: members AD and DC are horizontal (collinear), BD is vertical. No external load at D.




at joint D: AD and DC are collinear, BD is the odd member out, and no load acts at D

**Step 2 – Zero-force member identification (FE Handbook):** At a joint where two members are collinear and a third member is non-collinear, if there is no external load at that joint, the non-collinear member is a zero-force member.

**Step 3 – Apply at joint D:**




AD and DC are collinear • no external load at D

$\Sigma F_y = 0$ (perpendicular to the collinear pair): $F_{BD} = 0$

**$F_{BD} = 0 \rightarrow$ zero-force member (A)**

AD and DC are both horizontal (collinear). BD is vertical (non-collinear). No external load acts at D.

$$\sum F_y = 0: \quad F_{BD} = 0$$

**Step 4 – Answer:** $F_{BD} = 0\,\text{kN}$. BD is a zero-force member. Options (B), (C), and (D) all assign nonzero forces, which would violate vertical equilibrium at joint D. Zero-force members provide stability but carry no load under this loading.

**Correct answer: (A)**

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### Question 6 · Answer A

**Step 1 – Identify given information:**

| Shape | Area | Centroid $(\bar{x}_i, \bar{y}_i)$ |
|---|---|---|
| Rectangle $(10 \times 6)$ | $60\,\text{cm}^2$ | $(5, 3)$ |

| | | |
|---|---|---|
| Right triangle ($4 \times 6$) | $12\,\text{cm}^2$ | $(10 + 4/3, 6/3) = (11.33, 2)$ |

**Step 2 – Composite centroid (FE Handbook):**

$\bar{x} = \frac{\sum A_i \bar{x}_i}{\sum A_i}$, $\bar{y} = \frac{\sum A_i \bar{y}_i}{\sum A_i}$

**Step 3 – Substitute and solve:**

$$\bar{x} = \frac{60(5) + 12(11.33)}{60 + 12} = \frac{300 + 136}{72} = \frac{436}{72} = 6.056 \approx 6.06\,\text{cm}$$

$$\bar{y} = \frac{60(3) + 12(2)}{72} = \frac{180 + 24}{72} = \frac{204}{72} = 2.833 \approx 2.83\,\text{cm}$$

**Step 4 – Answer:** $(\bar{x}, \bar{y}) \approx (6.06, 2.83)$. The triangle pulls the centroid to the right and slightly down. Option (B) $(7, 3)$ overestimates; (C) and (D) are incorrect.

**Correct answer: (A)**

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### Question 7 · Answer A

**Step 1 – Identify given information:** Block on $30^\circ$ frictionless incline: $m_1 = 8\,\text{kg}$. Hanging mass: $m_2 = 5\,\text{kg}$. Frictionless pulley.

**Step 2 – System acceleration for incline-pulley system:** $a = \frac{g(m_2 - m_1 \sin\theta)}{m_1 + m_2}$.

**Step 3 – Substitute and solve:**

$$a = \frac{9.81(5 - 8 \times 0.5)}{8 + 5} = \frac{9.81(5 - 4)}{13} = \frac{9.81}{13} \approx 0.75\,\text{m/s}^2$$

**Step 4 – Answer:** The acceleration is $0.75\,\text{m/s}^2$. Since $m_2 g > m_1 g \sin 30^\circ$, the hanging mass descends and the incline mass moves up. The correct answer is **(A)**.

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### Question 8 · Answer C

**Step 1 – Identify given information:**

$L = 4.0\ \text{m}$, $w = 3.0\ \text{kN/m}$ (full span), $P = 6.0\ \text{kN}$ at center.

**Step 2 – Use superposition for maximum moment (FE Handbook):**

$M_{\text{total}} = \frac{wL^2}{8} + \frac{PL}{4}$ (both maxima at midspan)

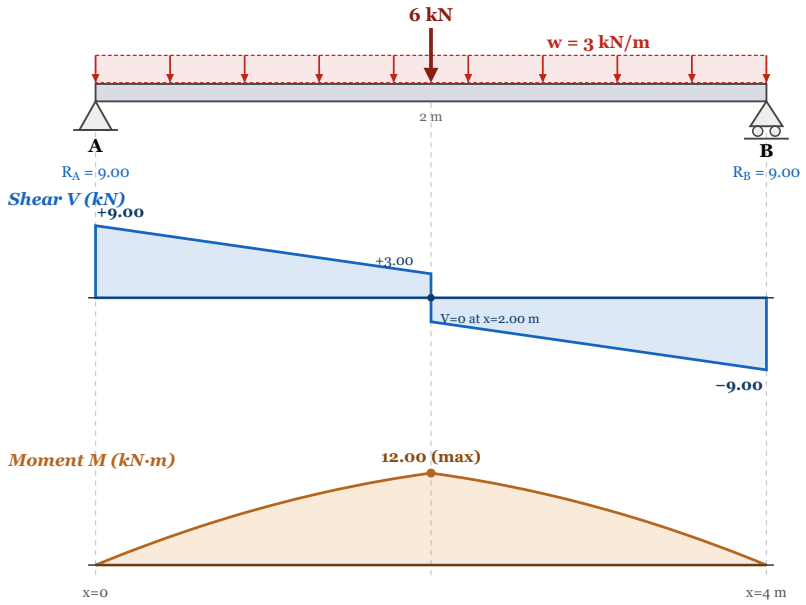
**Step 3 – Solve:**

$$M_{\text{UDL}} = \frac{3.0 \times (4.0)^2}{8} = 6\ \text{kN} \cdot \text{m}$$

$$M_{\text{point}} = \frac{6.0 \times 4.0}{4} = 6\ \text{kN} \cdot \text{m}$$

$$M_{\text{total}} = 6 + 6 = 12\ \text{kN} \cdot \text{m}$$

*Shear (V) and bending-moment (M) diagrams*




**Step 4 – Answer:** The maximum moment is $12\ \text{kN}\cdot\text{m}$. Superposition is valid because both load cases are linear elastic and their maxima occur at the same location.

**Correct answer: (C)**

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### Question 9 · Answer D

**Step 1 – Identify given information:** $x = 35$, $x_\alpha = 12$ and $x_\beta = 92$, all in weight percent B.

**Step 2 – Lever rule (Handbook p. 128):**

$$\text{wt\% } \alpha = \frac{x_\beta - x}{x_\beta - x_\alpha} \times 100$$

**Step 3 – Substitute and solve:**

$$\text{wt\% } \alpha = \frac{92 - 35}{92 - 12} \times 100 = \frac{57}{80} \times 100 = 71.3\%$$

**Step 4 – Answer:** About $71\%$ of the alloy is $\alpha$. Note that the arm used for $\alpha$ is the one reaching toward $\beta$: the phase whose composition lies *closer* to the overall composition is the more abundant one, and here $x = 35$ is much nearer $x_\alpha = 12$ than $x_\beta = 92$, so $\alpha$ must dominate.

Option (B) is the weight percent of $\beta$, which is what you get by taking the near arm instead of the far one, and the two always sum to $100\%$. Option (C) divides the overall composition by the $\beta$ boundary, $35/92$, which is not a lever at all. Option (A) simply reports the $\alpha$ boundary composition rather than the amount of $\alpha$.

**Correct answer: (D)**

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### Question 10 · Answer D

**Step 1 – Identify given information:**

| Parameter | Value |
|---|---|
| Orifice diameter $d$ | $40\ \text{mm} = 0.040\ \text{m}$ |
| $C_d$ | $0.62$ |
| Target $Q$ | $0.0060\ \text{m}^3/\text{s}$ |

**Step 2 – Orifice equation solved for head:** From the FE Handbook:

$$Q = C_d A\sqrt{2gh} \quad \Rightarrow \quad h = \frac{1}{2g}\left(\frac{Q}{C_d A}\right)^2$$

**Step 3 – Substitute and solve:**

$$A = \frac{\pi(0.04)^2}{4} = 1.257 \times 10^{-3}\ \text{m}^2$$

$$\frac{Q}{C_d A} = \frac{0.006}{0.62 \times 1.257 \times 10^{-3}} = \frac{0.006}{7.793 \times 10^{-4}} = 7.70\ \text{m/s}$$

$$h = \frac{(7.70)^2}{2 \times 9.81} = \frac{59.29}{19.62} = 3.02 \approx 3.0\ \text{m}$$

**Step 4 – Answer:** The correct answer is **(D) 3.0 m**. This is the inverse orifice problem -- given the desired flow rate, find the required head.

Option (B) is what you get by treating the head as linear outside the square root, writing h = Q/(C_d A √(2g)) instead of solving Q = C_d A √(2gh) for h.

---

**Question 11 · Answer B**

**Step 1 - Level formulas (not printed in the Handbook, so recall them):**
$HI = \text{Elev} + BS$ (add a backsight); $\text{Elev} = HI - FS$ (subtract a foresight).

**Step 2 - Carry the elevation through each setup:**
$HI_1 = 725.00 + 4.18 = 729.18$; $\text{Elev}_{TP1} = 729.18 - 6.72 = 722.46$
$HI_2 = 722.46 + 5.63 = 728.09$; $\text{Elev}_{TP2} = 728.09 - 8.10 = 719.99$
$HI_3 = 719.99 + 3.47 = 723.46$; $\text{Elev}_{4+00} = 723.46 - 7.25 = \mathbf{716.21}\ \text{ft}$

**Step 3 - Arithmetic check:**
$\sum BS - \sum FS = 13.28 - 22.07 = -8.79$, so $725.00 - 8.79 = 716.21\ \text{ft}$.

**Answer:** $716.21\ \text{ft}$ (B).
(A) drops all backsights; (C) swaps BS and FS; (D) adds backsights only.

**Correct answer: (B)**

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**Question 12 · Answer C**

**Step 1 – Identify given information:**

Triangular channel: depth $y = 2.0$ m, side slopes $z = 2$ (2H:1V).

**Step 2 – Triangular channel geometry (FE Handbook):**

$A = zy^2$, $P = 2y\sqrt{1+z^2}$, $R_h = A/P$

**Step 3 – Solve:**

$$A = 2 \times (2.0)^2 = 2 \times 4 = 8.0 \text{ m}^2$$

$$P = 2(2.0)\sqrt{1+4} = 4.0\sqrt{5} = 4.0 \times 2.236 = 8.944 \text{ m}$$

$$R_h = \frac{8.0}{8.944} = 0.895 \text{ m}$$

**Step 4 – Answer:** $R_h \approx 0.90$ m. For triangular channels, the hydraulic radius depends only on the depth and side slope. The wetted perimeter includes both sloped sides but no bottom width.

The mistake is splitting the square root across the sum in the wetted perimeter, using sqrt(1+z^2) = 1+z = 3 instead of sqrt(5) = 2.236, which inflates P to 12 m and shrinks the hydraulic radius to 8.0/12 = 0.67 m.

**Correct answer: (C)**

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**Question 13 · Answer D**

**Step 1 – Identify given information:**

| Parameter | Value |
|---|---|
| $D_1$ | 0.20 m |
| $D_2$ | 0.10 m |
| $v_1$ | 1.5 m/s |
| $p_2$ | 0 (gage) |

**Step 2 – Continuity and Bernoulli (FE Handbook):**

Continuity: $v_2 = v_1(D_1/D_2)^2$. Bernoulli (horizontal, no losses): $p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$.

**Step 3 – Solve:**

$$v_2 = 1.5 \times \left(\frac{0.20}{0.10}\right)^2 = 1.5 \times 4 = 6.0 \text{ m/s}$$

$$p_1 = \frac{1}{2}\rho(v_2^2 - v_1^2) = \frac{1}{2}(1000)(36 - 2.25) = \frac{1}{2}(1000)(33.75) = 16{,}875\ \text{Pa}$$

**Step 4 – Answer:** $p_1 \approx 16.9$ kPa. The pressure at section 1 must be higher to accelerate the flow through the constriction (Bernoulli effect).

(A) $3.4\,\text{kPa}$ scales the velocity by the diameter RATIO instead of its square in continuity, taking $v_2 = 3.0$ m/s rather than $6.0$, which underestimates the pressure difference by a factor of five.
(B) $4.2\,\text{kPa}$ and (C) $8.0\,\text{kPa}$ follow from neither route.

**Correct answer: (D)**

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### Question 14 · Answer C

**Step 1 – Identify given information:**

| | |
|---|---|
| Span | $L = 8\,\text{m}$ |
| Section C | $x = 3\,\text{m}$ from $A$ |
| Moving load | $P = 40\,\text{kN}$ |

**Step 2 – Moment IL peak ordinate:** The IL for bending moment at a section reaches its maximum when the unit load is directly at that section. The peak ordinate is:

$$\text{IL}_{\max} = \frac{x(L - x)}{L}$$

**Step 3 – Calculate:**

$$\text{IL}_{\max} = \frac{3 \times (8 - 3)}{8} = \frac{3 \times 5}{8} = 1.875\,\text{m}$$

$$M_{\max} = P \times \text{IL}_{\max} = 40 \times 1.875 = 75\,\text{kN}\cdot\text{m}$$

**Step 4 – Answer:** $M_{\max} = 75\,\text{kN}\cdot\text{m}$, matching option (C). The IL ordinate has units of length (m) because it represents the moment produced by a unit force. Option (D) $120\,\text{kN}\cdot\text{m}$ would correspond to $M = PL/4$ (midspan of a 12 m span).

**Correct answer: (C)**

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### Question 15 · Answer C

**Step 1 – Identify given information:**

| | |
|---|---|
| Span | $L = 8\,\text{m}$ |
| Uniform load | $w = 6\,\text{kN/m}$ |
| Modulus of elasticity | $E = 200\,\text{GPa} = 200 \times 10^6\,\text{kN/m}^2$ |

| | |
|---|---|
| Moment of inertia | $I = 5.0 \times 10^{-5}\,\text{m}^4$ |

**Step 2 – Handbook equation (p. 140):** For a simply supported beam with a uniform load over the whole span the table gives $v_{\max} = -\dfrac{5wL^4}{384EI}$ at midspan. The minus sign means downward; the question asks for the size of the deflection, $\delta_{\max} = \dfrac{5wL^4}{384EI}$.

**Step 3 – Substitute and solve:** Work in kN and m so the units cancel.

$$EI = (200 \times 10^6)(5.0 \times 10^{-5}) = 10{,}000\,\text{kN}\cdot\text{m}^2$$

Then, with $w$ in kN/m and $L$ in m:

$$\delta_{\max} = \frac{5(6)(8)^4}{384(10{,}000)} = 0.032\,\text{m}$$

**Step 4 – Answer:** $\delta_{\max} = 32\,\text{mm}$, matching option (C). Option (A), $6.4\,\text{mm}$, leaves out the factor 5. Option (B), $16\,\text{mm}$, uses $5wL^4/(768EI)$, the next row of the table, which is for a load over only half the span. Option (D), $51\,\text{mm}$, replaces the load by its resultant $wL = 48\,\text{kN}$ at midspan and uses $PL^3/(48EI)$; a load spread along the span deflects the beam less than the same total load concentrated at the center.

**Correct answer: (C)**

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### Question 16 · Answer C

**Step 1 – Identify given information:**

| | |
|---|---|
| Retained height | $H = 5\,\text{m}$ |
| Unit weight | $\gamma = 19\,\text{kN/m}^3$ |
| Friction angle, cohesion | $\phi = 32^\circ$, $c = 0$ |
| Surcharge | $q = 12\,\text{kPa}$ |
| Water table | below the base (no pore pressure) |

**Step 2 – Handbook equations (p. 269):** For a smooth wall with level backfill and $c = 0$, $K_A = \tan^2(45^\circ - \phi/2)$. A layer of height $H$ whose effective vertical stress is $\sigma'_1$ at its top and $\sigma'_2$ at its base pushes on the wall with $P_A = \sigma'_1 K_A H + \frac{1}{2}(\sigma'_2 - \sigma'_1)K_A H$. The surcharge makes the vertical stress at the surface $\sigma'_1 = q$ instead of zero, so the pressure diagram is a rectangle (first term) plus a triangle (second term).

**Step 3 – Solve:**

$$K_A = \tan^2\left(45^\circ - \frac{32^\circ}{2}\right) = \tan^2 29^\circ = 0.3073$$

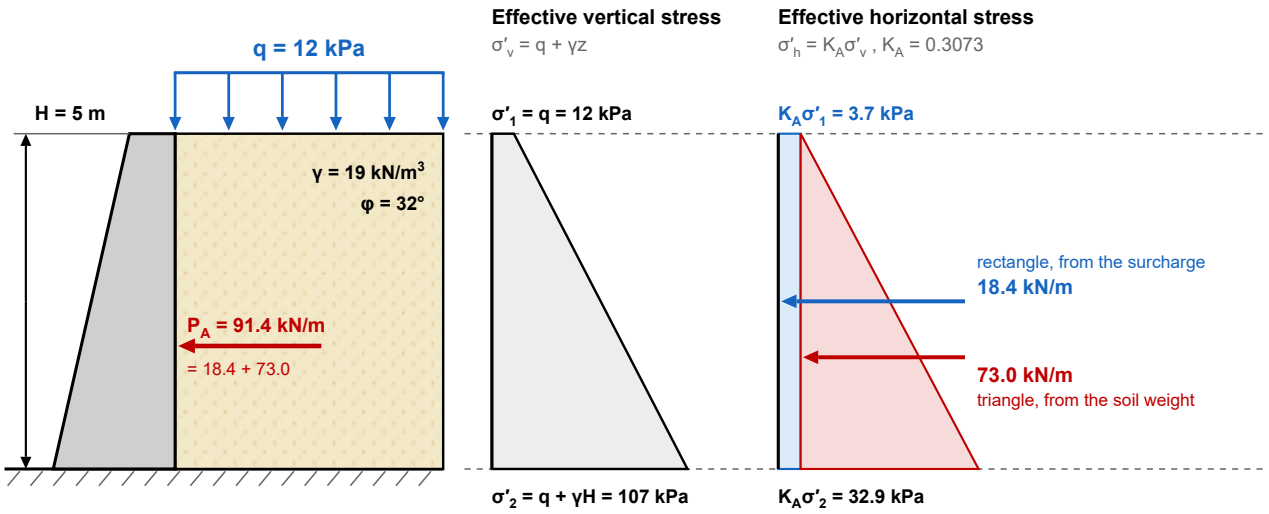
The effective vertical stress is $\sigma'_1 = q = 12\,\text{kPa}$ at the surface and $\sigma'_2 = q + \gamma H = 12 + 19(5) = 107\,\text{kPa}$ at the base, so:

$$P_A = 12(0.3073)(5) + \tfrac{1}{2}(107 - 12)(0.3073)(5)$$

The first term, the rectangle, is $18.4\,\text{kN/m}$ and the second, the triangle, is $73.0\,\text{kN/m}$:

$$P_A = 18.4 + 73.0 = 91.4\,\text{kN/m}$$

*Stress profiles in the layout of Handbook p. 269*




*Each diagram is drawn to its own stress scale; the proportions inside each one are true.*

**Step 4 – Answer:** $P_A \approx 91\,\text{kN/m}$ matches option (C). Option (A), 73, is the soil triangle alone, $\frac{1}{2}K_A\gamma H^2$, with the surcharge left out. Option (B), 82, takes the surcharge pressure as a triangle, $\frac{1}{2}K_A q H = 9.2$, when it is constant with depth and gives $K_A q H = 18.4$. Option (D), 133, adds the surcharge as $qH = 60$ without multiplying by $K_A$.

**Correct answer: (C)**

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### Question 17 · Answer A

**Step 1 – Identify given information:** Sieve analysis data (percent passing at various sieve sizes). Read $D_{10}$, $D_{30}$, $D_{60}$ from the semi-log grain-size distribution curve.

**Step 2 – Gradation coefficient formulas:** From the FE Handbook: $C_u = \dfrac{D_{60}}{D_{10}}$ and $C_c = \dfrac{D_{30}^2}{D_{10} \times D_{60}}$

**Step 3 – Solve:**

From interpolation on the curve: $D_{10} \approx 0.067\,\text{mm}$, $D_{30} \approx 0.163\,\text{mm}$, $D_{60} \approx 0.578\,\text{mm}$

$$C_u = \frac{0.578}{0.067} \approx 8.7$$

$$C_c = \frac{(0.163)^2}{0.067 \times 0.578} = \frac{0.02657}{0.03873} \approx 0.69$$

**Step 4 – Answer:** $C_u \approx 8.7$ and $C_c \approx 0.69$ match option (A). Since $C_u > 6$ but $C_c < 1$ (needs $1 \le C_c \le 3$ for well-graded), this soil is poorly graded despite having a wide range of particle sizes.

Option (C) is close to what LINEAR interpolation between the bracketing sieve sizes gives in place of interpolation on the log scale: it inflates $D_{60}$ more than $D_{10}$, pushes $C_u$ up and makes the soil look well graded. Option (B) keeps the right $C_u$ with a $C_c$ inside the well-graded band, and option D does not follow from the data.

**Correct answer: (A)**

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### Question 18 · Answer B

**Step 1 – Identify given information:**

Crest curve: $L = 500$ ft, $g_1 = +2.0\%$, $g_2 = -1.0\%$, PVC at sta 10+00.

**Step 2 – Condition for the high point:**

The grade along the parabola varies linearly, $g(x) = g_1 + \dfrac{g_2 - g_1}{L}\,x$, and the highest point occurs where it passes through zero:

$$x = \frac{-g_1 L}{g_2 - g_1} = \frac{-(0.02)(500)}{-0.010 - 0.020} = \frac{-10}{-0.030} = 333.3\ \text{ft from the PVC}$$

**Step 3 – Station of the high point:**

$$\text{sta} = 10 + 00\ +\ 333.3 = \text{sta}\ 13 + 33.3 \approx \text{sta}\ 13 + 33$$

**Step 4 – Answer:** sta $13 + 33$. Because $|g_1| = 2|g_2|$, the high point sits at two-thirds of the curve — option (A) $12 + 50$ is the midcurve trap (only valid when $|g_1| = |g_2|$), and (D) $11 + 67$ results from using $g_2$ in the numerator (that distance is measured from the PVT, not the PVC).

**Correct answer: (B)**

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### Question 19 · Answer D

**Step 1 – Identify given information:**

| | |
|---|---|
| Intersection angle | $\Delta = 58°20' = 58.333°$ |
| Long chord | $LC = 760$ ft |

**Step 2 – Long chord formula:** From the FE Handbook, the long chord of a simple circular curve relates to the radius and intersection angle by:

$$LC = 2R\sin\left(\frac{\Delta}{2}\right)$$

Rearranging for $R$: $R = \dfrac{LC}{2\sin(\Delta/2)}$

**Step 3 – Substitute and solve:**

$$R = \frac{760}{2\sin(58.333^\circ/2)} = \frac{760}{2\sin(29.167^\circ)} = \frac{760}{2(0.4873)} = \frac{760}{0.9747} = 779.7 \text{ ft}$$

**Step 4 – Answer:** Rounded to the nearest $10$ ft: $R \approx 780$ ft. Option (B) $730$ is too small, (C) $760$ would be the radius only if $\Delta$ were exactly $60^\circ$ ($\sin 30^\circ = 0.5$) — a tempting round-number trap, and (D) $820$ overshoots the calculation.

(A) $450\,\text{ft}$ puts the full intersection angle into the long-chord relation, dividing by $2\sin(58^\circ 20')$ instead of $2\sin(29^\circ 10')$.
(B) $730\,\text{ft}$ is close to the answer but follows from neither route.
(C) $760\,\text{ft}$ is the long chord itself, not the radius.

**Correct answer: (D)**

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### Question 20 · Answer A

**Step 1 – Identify given information:**

AON: A(3), B(5) start; C(4) after A; D(6) after A and B; E(2) after C; F(3) after D and E. Find the total float of E.

**Step 2 – Forward pass (ES → EF):**

A: 0→3 • B: 0→5 • C: 3→7 • D: max(3, 5) = 5→11 • E: 7→9 • F: max(11, 9) = 11→14

**Step 3 – Backward pass through E:**

Duration 14 (critical path B–D–F). $LS_F = 14 - 3 = 11 \Rightarrow LF_E = 11 \Rightarrow LS_E = 11 - 2 = 9$

**Step 4 – Total float:**

$$TF_E = LS_E - ES_E = 9 - 7 = 2 \text{ days}$$

**Correct answer: (A)**

Both larger options come from real CPM slips that inflate the float. Option (C) omits the successor's duration in the backward pass, using F's late finish (14) as E's late finish. Option (D) adds the individual total floats of A, C and E ($2 + 2 + 2$) as if each activity had its own slack, when the whole path shares a single 2-day float.

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