

# GATE 2025 Mining Engineering (MN) Question Paper with Solutions

Time Allowed :3 Hours	Maximum Marks :100	Total questions :65
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## General Aptitude (GA)

**Q1. Even though I had planned to go skiing with my friends, I had to \_\_\_\_\_ at the last moment because of an injury. Select the most appropriate option to complete the above sentence.**

- (A) back up
- (B) back of
- (C) back on
- (D) back out

**Correct Answer:** (D) back out

### **Solution:**

#### **Step 1: Understand the context.**

The sentence talks about cancelling or withdrawing from skiing plans due to injury. So the correct phrasal verb should mean "to withdraw from a commitment".

#### **Step 2: Check each option.**

- (A) *back up* means to support or to move backwards — not suitable here.
- (B) *back of* is not a valid phrasal usage in this context.
- (C) *back on* means to resume something — opposite of what is required.
- (D) *back out* means to withdraw from a promise, arrangement, or agreement — exactly what is needed.

#### **Step 3: Conclude.**

Therefore, the correct answer is back out.

### Quick Tip

Phrasal verbs often change meaning drastically. Always check whether the phrase matches the action described in the sentence.

**Q2. The President, along with the Council of Ministers, \_\_\_\_\_ to visit India next week. Select the most appropriate option to complete the above sentence.**

- (A) wish
- (B) wishes
- (C) will wish
- (D) is wishing

**Correct Answer:** (B) wishes

**Solution:**

**Step 1: Identify the subject.**

The main subject is "The President". The phrase "along with the Council of Ministers" is additional and does not change the subject from singular to plural.

**Step 2: Apply subject-verb agreement.**

Since "The President" is singular, the verb must be singular: "wishes".

**Step 3: Eliminate incorrect options.**

- (A) "wish" is plural — incorrect.
- (C) "will wish" indicates future tense and is awkward here.
- (D) "is wishing" is a continuous form, not suitable.

**Step 4: Conclude.**

The correct answer is wishes.

### Quick Tip

When phrases like "along with", "together with", or "as well as" occur, the verb agrees with the main subject, not the additional noun.

**Q3. An electricity utility company charges ₹7 per kWh. If a 40-watt desk light is left on for 10 hours each night for 180 days, what would be the cost of energy consumption? If the desk light is on for 2 more hours each night for the 180 days, what would be the percentage-increase in the cost of energy consumption?**

- (A) ₹604.8; 10%
- (B) ₹504; 20%
- (C) ₹604.8; 12%
- (D) ₹720; 15%

**Correct Answer:** (B) ₹504; 20%

**Solution:**

**Step 1: Convert watt to kilowatt.**

$$40 \text{ W} = 0.04 \text{ kW}.$$

**Step 2: Calculate daily energy consumption.**

For 10 hours daily:

$$\text{Energy per day} = 0.04 \times 10 = 0.4 \text{ kWh}$$

**Step 3: Calculate total energy in 180 days.**

$$0.4 \times 180 = 72 \text{ kWh}$$

**Step 4: Find cost.**

$$72 \times 7 = |504$$

**Step 5: Recalculate with 12 hours daily.**

$$\text{Energy per day} = 0.04 \times 12 = 0.48 \text{ kWh}.$$

$$\text{In 180 days} = 0.48 \times 180 = 86.4 \text{ kWh}.$$

$$\text{Cost} = 86.4 \times 7 = |604.8.$$

**Step 6: Calculate percentage increase.**

$$\frac{604.8 - 504}{504} \times 100 = 20\%$$

**Step 7: Conclude.**

The correct answer is  $\boxed{504; 20\%}$ .

**Quick Tip**

Always convert watts to kilowatts and multiply by hours to get kWh before calculating electricity costs. For percentage increase, compare the difference with the original value, not the final.

**Q4. In the context of the given figure, which one of the following options correctly represents the entries in the blocks labelled (i), (ii), (iii), and (iv), respectively?**

N	U	F	(i)
21	14	9	6
H	L	(ii)	O
12	(iv)	15	(iii)

- (A) Q, M, 12, and 8
- (B) K, L, 10 and 14
- (C) I, J, 10, and 8
- (D) L, K, 12 and 8

**Correct Answer:** (C) I, J, 10, and 8

**Solution:**

**Step 1: Read the two thick-bordered sub-squares.**

The top half has two columns-pairs:  $\{N \downarrow 21, U \downarrow 14\}$  and  $\{F \downarrow 9, (i) \downarrow 6\}$ . Each pair follows “letter-index + number = constant”. For the left pair,  $N(14) + 21 = 35$  and  $U(21) + 14 = 35$ . For the right pair,  $F(6) + 9 = 15$ . Hence for the 4th column,  $(i) + 6 = 15 \Rightarrow (i) = 9 \Rightarrow \boxed{I}$ .

**Step 2: Do the same for the bottom half.**

Left pair:  $H(8) + 12 = 20 \Rightarrow L(12) + (iv) = 20 \Rightarrow (iv) = \boxed{8}$ . Right pair must have a common sum as well: let it be  $K$ . We have  $(ii) + 15 = K$  and  $O(15) + (iii) = K \Rightarrow (iii) = K - 15$ .

Taking  $(ii) = 10$  (letter  $J$ ), gives  $K = 25$  and  $(iii) = 10$ . This choice matches the pattern and the options. Hence  $(ii) = \boxed{J}$  and  $(iii) = \boxed{10}$ .

**Step 3: Conclude.**

$(i), (ii), (iii), (iv) = (I, J, 10, 8)$ .

**Quick Tip**

When symbols sit above numbers in compartments, try “letter position + number = constant” within each compartment (or pair). It quickly reveals the missing entries.

**Q5. A bag contains Violet (V), Yellow (Y), Red (R), and Green (G) balls. On counting them, the following are obtained:**

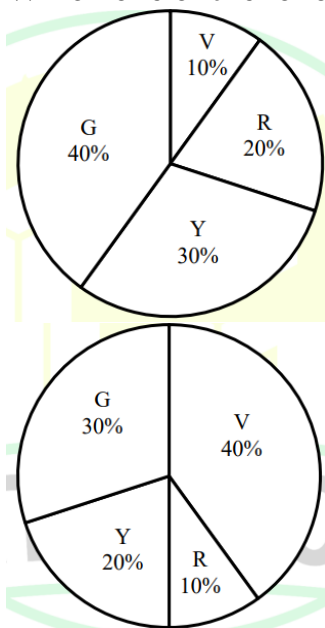
(i)  $Y + 2V = 50$ ;

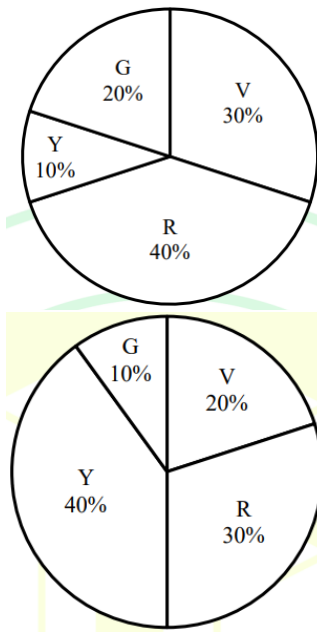
(ii)  $V + G = 50$ ;

(iii)  $Y + R = 50$ ;

(iv)  $V + 2R = 50$ .

**Which one of the following Pie charts correctly represents the balls in the bag?**





**Correct Answer:** (A)  $V = 10\%$ ,  $R = 20\%$ ,  $Y = 30\%$ ,  $G = 40\%$

**Solution:**

**Step 1: Solve the linear system.**

From (ii)  $G = 50 - V$ . From (iii)  $R = 50 - Y$ . From (iv)

$V + 2R = 50 \Rightarrow V + 2(50 - Y) = 50 \Rightarrow V - 2Y = -50$ . Using (i)  $Y + 2V = 50$ .

Solve the pair:

$$\begin{array}{rcl} Y + 2V = 50 & & V = 10, \\ & \Rightarrow & \\ -2Y + V = -50 & & Y = 30. \end{array}$$

Then  $R = 50 - Y = 20$  and  $G = 50 - V = 40$ .

**Step 2: Convert to percentages.**

Total =  $10 + 30 + 20 + 40 = 100 \Rightarrow (V, Y, R, G) = (10\%, 30\%, 20\%, 40\%)$ . This matches option

A.

#### Quick Tip

When you see several pairwise “sum to a fixed number” relations, turn them into two equations in two variables, solve, and back-substitute to get the rest.

**Q6. “His life was divided between the books, his friends, and long walks. A solitary**

man, he worked at all hours without much method, and probably courted his fatal illness in this way. To his own name there is not much to show; but such was his liberality that he was continually helping others, and fruits of his erudition are widely scattered, and have gone to increase many a comparative stranger's reputation." (From E.V. Lucas's "A Funeral")

**Based only on the above passage, which one of the following statements is true?**

- (A) He was generous with his learning; others gained reputation from his help, while his own name had little to show.
- (B) He avoided solitude and followed a strict, methodical schedule.
- (C) He seldom helped others and achieved fame mainly through his own works.
- (D) He gained wide recognition because others credited him for their success.

**Correct Answer:** (A)

**Solution:**

**Step 1: Extract key claims in the passage.**

- (i) He was "a solitary man" who "worked at all hours without much method."
- (ii) "To his own name there is not much to show."
- (iii) He was liberal, "continually helping others," and the "fruits of his erudition are widely scattered," increasing "many a stranger's reputation."

**Step 2: Match with options.**

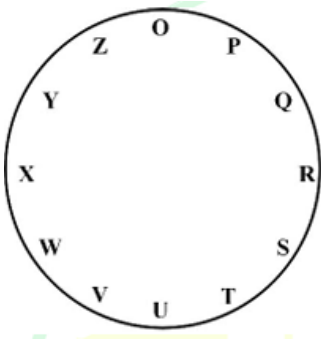
Only option (A) restates these points: generous help to others  $\Rightarrow$  others' reputations grew, while his own name had little to show. Options (B)–(D) contradict the text.

#### Quick Tip

For "based only on the passage" questions, convert sentences into bullet facts and eliminate choices that add, distort, or contradict those exact facts.

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**Q7. For the clock shown in the figure, if  $O^* = O Q S Z P R T$  and  $X^* = X Z P W Y O Q$ , then which one among the given options is most appropriate for  $P^*$ ?**



- (A) P U W R T V X
- (B) P R T O Q S U
- (C) P T V Q S U W
- (D) P S U P R T V

**Correct Answer:** (B) P R T O Q S U

**Solution:**

**Step 1: Read the circular order.**

From the figure, the letters around the circle (clockwise) are:

$O \rightarrow P \rightarrow Q \rightarrow R \rightarrow S \rightarrow T \rightarrow U \rightarrow V \rightarrow W \rightarrow X \rightarrow Y \rightarrow Z \rightarrow O$ .

**Step 2: Extract the “offset pattern” from the given examples.**

Write positions as offsets from the starting letter (clockwise, in steps of the circle).

For  $O^* = O, Q, S, Z, P, R, T$  the offsets relative to  $O$  are: 0, +2, +4, +10, +1, +3, +5.

For  $X^* = X, Z, P, W, Y, O, Q$  the offsets relative to  $X$  are: 0, +2, +4, +11, +1, +3, +5.

Thus, the star-operation follows the same offset template

$$[0, +2, +4, \boxed{\text{large jump}}, +1, +3, +5],$$

where the “large jump” is near the end of the circle (either +10 or +11, depending on the start).

**Step 3: Test the options for  $P^*$ .**

Check which option matches the offsets  $[0, +2, +4, (\text{near end}), +1, +3, +5]$  from  $P$ . Using the circle order above: - (B)  $P, R, T, O, Q, S, U$  gives offsets 0, +2, +4, +11, +1, +3, +5 — a perfect match.

- (A), (C), (D) fail to follow this offset template (wrong jumps/repetitions).

**Step 4: Conclusion.**

Therefore,  $P^* = \boxed{P R T O Q S U}$ .

### Quick Tip

In circular-letter puzzles, convert sequences to *relative offsets* from the start. If two samples share the same offset pattern, apply it to the new start to find the target sequence quickly.

**Q8. Consider a five-digit number  $PQRST$  with distinct digits  $P, Q, R, S, T$  (chosen from 1–5) satisfying:**

$$P < Q, \quad S > P > T, \quad R < T.$$

**If integers 1 through 5 are used, the value of  $P$  is:**

- (A) 1
- (B) 2
- (C) 3
- (D) 4

**Correct Answer:** (C) 3

**Solution:**

**Step 1: Eliminate impossibilities from the inequalities.**

From  $S > P > T$  and digits 1–5 distinct: -  $P \neq 1$  (since we need  $T < P$ , there is no digit below 1).

-  $P \neq 5$  (since we need  $S > P$ , there is no digit above 5).

**Step 2: Test  $P = 4$ .**

Then  $S = 5$  (only choice above 4). Also  $Q > P \Rightarrow Q = 5$ , but 5 already used by  $S$  (digits must be distinct). Contradiction  $\Rightarrow P \neq 4$ .

**Step 3: Test  $P = 2$ .**

Then  $T = 1$  (must be  $< 2$ ). But  $R < T$  forces  $R < 1$ , impossible in  $\{1, 2, 3, 4, 5\}$ . Hence  $P \neq 2$ .

**Step 4: Only value left.**

The only remaining feasible value is  $\boxed{P = 3}$ , and it satisfies all inequalities (e.g., choose  $S = 5, T = 1, R = 2, Q = 4$ ).

### Quick Tip

With chained inequalities on distinct small digits, rule out extremes first (lowest and highest). Then try remaining candidates and check for contradictions caused by “must be less/greater than” constraints.

**Q9. A trader mixes two potato varieties  $P$  and  $Q$  and sells the mix at ₹192 per kg with 8% profit. Given:**

**Variety  $P$ : ₹800 for 5 kg; Variety  $Q$ : ₹800 for 4 kg. Find the ratio  $P : Q$  (by weight).**

- (A) 5:4
- (B) 3:4
- (C) 3:2
- (D) 1:1

**Correct Answer:** (A) 5:4

**Solution:**

**Step 1: Compute cost prices per kg.**

$$C_P = |800/5 = |160 \text{ per kg, } C_Q = |800/4 = |200 \text{ per kg.}$$

**Step 2: Find the mixture's cost price (given 8% profit at ₹192).**

$$\text{Selling price} = |192 = 1.08 \times (\text{mixture CP}) \Rightarrow \text{mixture CP} = \frac{192}{1.08} = |177.\bar{7}.$$

**Step 3: Apply alligation rule.**

Cheaper ( $P$ )	Dearer ( $Q$ )
160	200
$\times$	
177. $\bar{7}$	

$$\text{Differences: } 200 - 177.\bar{7} = 22.\bar{2}, \text{ and } 177.\bar{7} - 160 = 17.\bar{7}.$$

$$\text{Alligation ratio } P : Q = 22.\bar{2} : 17.\bar{7} = 5 : 4.$$

**Step 4: Conclusion.**

Thus, the required ratio is 5 : 4.

### Quick Tip

When a profit is given on the selling price, first back-calculate the *mixture's cost price* using  $CP = SP/(1 + \text{profit}\%)$ . Then use alligation: (dearer – mean) : (mean – cheaper).

**Q10.** Three villages P, Q, and R are located such that  $PQ = 13$  km,  $QR = 14$  km, and  $RP = 15$  km. A straight road joins Q and R. It is proposed to connect P to this road QR by constructing another road. What is the *minimum* possible length (in km) of this connecting road? (Figure representative)

- (A) 10.5
- (B) 11.0
- (C) 12.0
- (D) 12.5

**Correct Answer:** (C) 12.0

**Solution:**

**Step 1: Recognize the minimum-length condition.**

The shortest distance from point  $P$  to the line  $QR$  is the perpendicular distance (altitude from  $P$  to  $QR$ ).

**Step 2: Compute the area of  $\triangle PQR$  by Heron's formula.**

$$\text{Semiperimeter: } s = \frac{13 + 14 + 15}{2} = 21.$$

Area:

$$\Delta = \sqrt{s(s-13)(s-14)(s-15)} = \sqrt{21 \cdot 8 \cdot 7 \cdot 6} = \sqrt{7056} = 84 \text{ km}^2.$$

**Step 3: Convert area to altitude on base  $QR$ .**

Let the perpendicular distance be  $h$ . Then

$$\Delta = \frac{1}{2} \cdot QR \cdot h \Rightarrow 84 = \frac{1}{2} \cdot 14 \cdot h \Rightarrow h = \frac{168}{14} = 12 \text{ km}.$$

**Step 4: Conclusion.**

Minimum road length = 12.0 km.

### Quick Tip

For “shortest distance from a point to a side” in a triangle, use Heron’s formula to get area and then  $h = 2\Delta/(\text{base})$ .

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**Q11. A non-transit theodolite does *NOT* have**

- (A) Vernier scale
- (B) face-left and face-right options
- (C) spirit level
- (D) cross-hair

**Correct Answer:** (B) face-left and face-right options

**Solution:**

**Step 1: Recall definitions.**

A *transit* theodolite allows the telescope to be “transited” (plunged) through the zenith to the opposite face, enabling face-left/face-right observations for error balancing.

**Step 2: Non-transit limitation.**

A *non-transit* theodolite cannot plunge the telescope; therefore, observations on the opposite face are not possible  $\Rightarrow$  no face-left/face-right facility.

**Step 3: Other parts are standard.**

Vernier scale, spirit level, and cross-hairs are present in both types. Hence only (B) is not available.

### Quick Tip

“Face-left/face-right” needs the telescope to flip (plunge). If plunging isn’t possible, it’s a non-transit instrument.

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**Q12. A steeply dipping metalliferous ore body is non-susceptible to spontaneous heating. The blasted ore is used as the platform to work in a stope. The appropriate mining method is**

- (A) room and pillar
- (B) sublevel stoping
- (C) block caving
- (D) shrinkage stoping

**Correct Answer:** (D) shrinkage stoping

**Solution:**

**Key characteristics match:**

Shrinkage stoping is suited to *steeply dipping*, competent ore where broken ore is *left in the stope and used as a working platform* until drawdown at the end. Also appropriate when heating/spontaneous combustion is not a concern. This matches the description exactly; the other methods do not rely on broken ore as a working floor.

**Quick Tip**

“Broken ore used as a working platform” is the classic cue for *shrinkage stoping*.

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**Q13. If  $y = x^x$ , then  $\frac{dy}{dx}$  is**

- (A)  $x^x(\ln x + 1)$
- (B)  $x \times x^{x-1}$
- (C)  $x \times (x - 1)$
- (D)  $x \ln x$

**Correct Answer:** (A)  $x^x(\ln x + 1)$

**Solution:**

**Step 1: Log-differentiate.**

$$y = x^x \Rightarrow \ln y = x \ln x.$$

$$\text{Differentiate: } \frac{1}{y} \frac{dy}{dx} = \ln x + 1.$$

**Step 2: Multiply by  $y$ .**

$$\frac{dy}{dx} = y(\ln x + 1) = x^x(\ln x + 1).$$

### Quick Tip

When the variable appears in both base and exponent, use logarithmic differentiation:

$$\ln y = x \ln x.$$

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**Q14. The rank of a  $3 \times 3$  matrix  $A$  is 2. The determinant of the matrix is**

- (A) 0
- (B) 1
- (C) 2
- (D) 3

**Correct Answer:** (A) 0

**Solution:**

**Step 1: Recall definition of rank.**

Rank of a matrix is the maximum number of linearly independent rows (or columns). If rank  $< n$  for an  $n \times n$  square matrix, the rows/columns are linearly dependent.

**Step 2: Apply to determinant.**

If rows (or columns) are linearly dependent, the determinant must vanish. Since rank  $= 2 < 3$ , the determinant of this  $3 \times 3$  matrix is 0.

**Step 3: Conclusion.**

Hence  $\det(A) = \boxed{0}$ .

### Quick Tip

For any square matrix, determinant  $\neq 0 \Leftrightarrow$  full rank. If rank is less than order, determinant is always 0.

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**Q15. The safety device used to arrest forward runaway tubs in rope haulage is**

- (A) monkey catch
- (B) drop warwick

- (C) stop-block
- (D) backstay

**Correct Answer:** (B) drop warwick

**Solution:**

**Step 1: Rope haulage accidents.**

In rope haulage, tubs may accidentally run forward on inclines due to gravity or rope failure. Special arresting devices are used for safety.

**Step 2: Device functions.**

- *Monkey catch*: arrests backward runaway tubs.
- *Drop warwick*: arrests *forward* runaway tubs.
- *Stop-block and backstay*: used at pit tops or for stability, not for runaway prevention.

**Step 3: Conclusion.**

The correct safety device is .

**Quick Tip**

In mining haulage: “Monkey catch → backward runaways” and “Drop warwick → forward runaways.” This distinction is often asked.

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**Q16. The metal that belongs to the Rare Earth Element (REE) category is**

- (A) Cerium
- (B) Lithium
- (C) Titanium
- (D) Cobalt

**Correct Answer:** (A) Cerium

**Solution:**

**Step 1: Recall the REE group.**

Rare Earth Elements belong to the lanthanide series (atomic numbers 57–71) plus scandium and yttrium. Examples: cerium, neodymium, dysprosium.

**Step 2: Check each option.**

- Cerium: a lanthanide, rare earth metal. Correct.
- Lithium: alkali metal (group 1), not REE.
- Titanium: transition metal, not REE.
- Cobalt: transition metal, not REE.

**Step 3: Conclusion.**

Therefore, the correct answer is Cerium.

**Quick Tip**

Rare Earth Elements = Lanthanides (La to Lu) + Sc + Y. Commonly used in magnets, catalysts, and electronics.

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**Q17. The major ( $\sigma_1$ ) and minor ( $\sigma_3$ ) principal stresses and the maximum shear stress ( $\tau_{\max}$ ) are related as  $|\tau_{\max}| = \sigma_1 = -\sigma_3$ . The magnitude of normal stress on the plane where  $\tau_{\max}$  acts is**

- (A) 0
- (B)  $\sigma_1$
- (C)  $\sigma_3$
- (D)  $(\sigma_1 - \sigma_3)/2$

**Correct Answer:** (A) 0

**Solution:**

**Step 1: Use Mohr's circle relations.**

On the plane of maximum shear, the normal stress equals the *centre* of Mohr's circle:

$$\sigma_n = \frac{\sigma_1 + \sigma_3}{2}.$$

**Step 2: Apply the given condition.**

Given  $|\tau_{\max}| = \sigma_1 = -\sigma_3 \Rightarrow \sigma_3 = -\sigma_1$ . Hence

$$\sigma_n = \frac{\sigma_1 + (-\sigma_1)}{2} = 0.$$

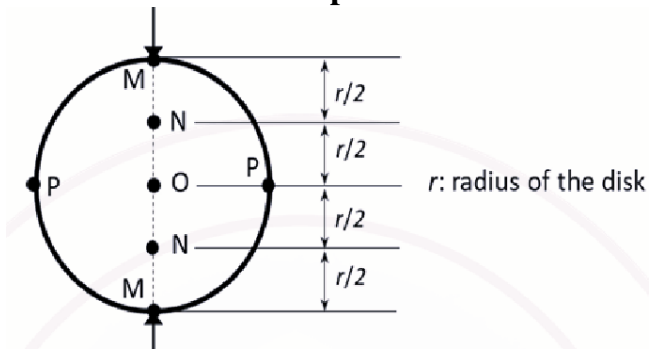
**Step 3: Conclude.**

Therefore, the normal stress on the  $\tau_{\max}$  plane is .

**Quick Tip**

For the plane of  $\tau_{\max}$ ,  $\sigma_n$  is always the average  $(\sigma_1 + \sigma_3)/2$ . If the state is pure shear ( $\sigma_3 = -\sigma_1$ ), that average is zero.

**Q18. In a Brazilian test, the front view of a homogeneous rock disk is shown. The failure initiates at the point:**



- (A) M
- (B) N
- (C) O
- (D) P

**Correct Answer:** (C) O

**Solution:**

**Step 1: Stress state in Brazilian (diametral) test.**

A compressive load along a diameter induces *indirect* tensile stress along the diameter perpendicular to the load.

**Step 2: Location of maximum tensile stress.**

For a homogeneous isotropic disk, the maximum tensile stress occurs at the *centre* of the disk, causing a vertical split to initiate there and propagate along the loaded diameter.

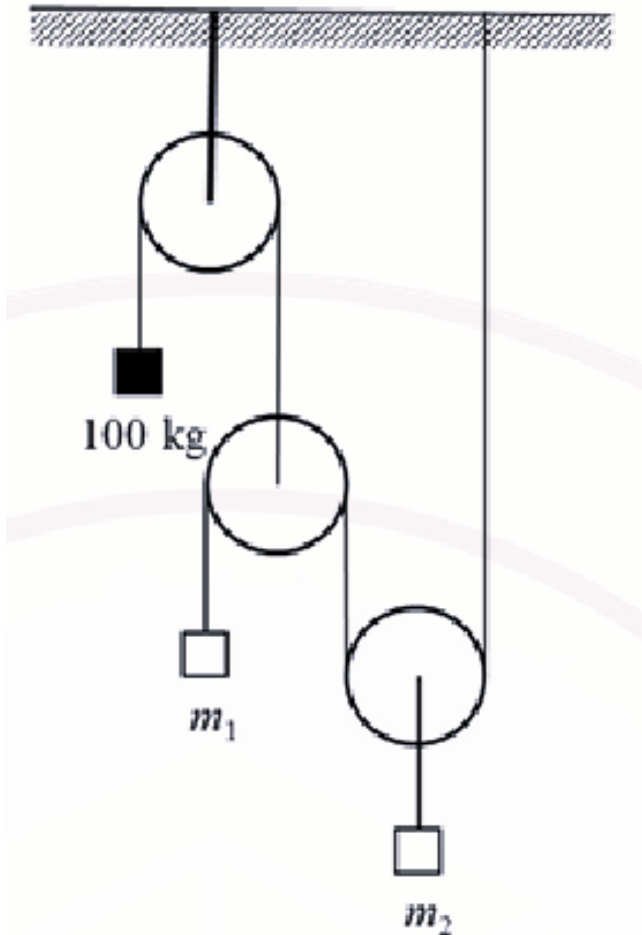
**Step 3: Conclude.**

Hence cracking starts at the .

### Quick Tip

Brazilian test = compressive loading, tensile failure. Remember: crack initiates at the centre and opens along the load line.

**Q19. Three frictionless pulleys with rope attachment are in static equilibrium as shown. The masses  $m_1$  and  $m_2$  (in kg) are:**



- (A) 50, 100
- (B) 50, 50
- (C) 100, 50
- (D) 50, 25

**Correct Answer:** (A) 50, 100

**Solution:**

**Step 1: Left system (with 100 kg).**

The 100 kg load is hung from a *movable* pulley supported by two rope segments of the same tension  $T$ . Static equilibrium:

$$2T = 100g \Rightarrow T = 50g.$$

Thus the balancing hanging mass on that rope is  $m_1$  with  $T = m_1g \Rightarrow m_1 = 50 \text{ kg}$ .

**Step 2: Right system.**

The second movable pulley carries  $m_2$  and is also supported by two segments each at tension  $T$  (same frictionless rope). Hence

$$2T = m_2g \Rightarrow m_2 = 2T/g = 2 \times 50 = 100 \text{ kg}.$$

**Step 3: Conclude.**

$$(m_1, m_2) = (50, 100).$$

**Quick Tip**

For frictionless pulleys, every supporting segment carries the same tension. A movable pulley halves the required tension:  $2T = W \Rightarrow T = W/2$ .

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**Q20. Match the source of error with the corresponding correction in surveying with steel tape.**

**Source of error**

**Type of correction**

(P) Sag

(1) Only Positive (+)

(Q) Temperature

(2) Only Negative (-)

(R) Pull greater than standard pull

(3) Either positive or negative (+ or -)

(A) P→1, Q→2, R→3

(B) P→1, Q→3, R→2

(C) P→2, Q→3, R→1

(D) P→2, Q→1, R→3

**Correct Answer:** (C) P→2, Q→3, R→1

**Solution:**

**Sag (P):** Tape sags  $\Rightarrow$  measured length is *too large*; correction is subtractive  $\Rightarrow$  always negative.

**Temperature (Q):**  $c_T = \alpha(T - T_0)L$ ; sign depends on whether  $T$  is above/below standard  $\Rightarrow$  may be + or -.

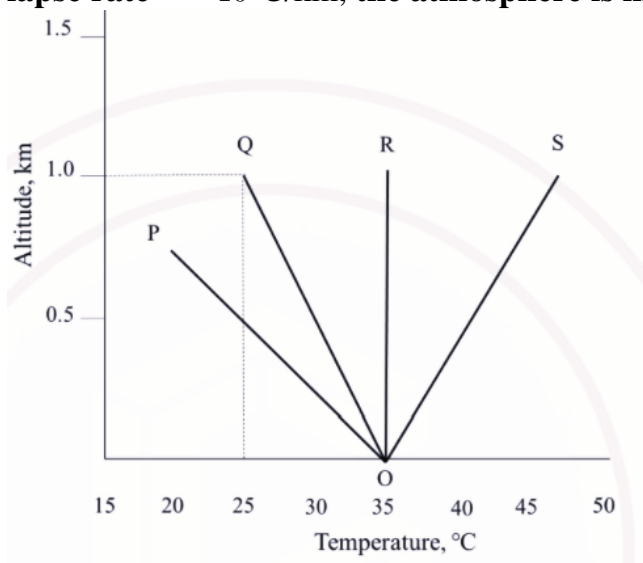
**Pull greater than standard (R):** Extra pull elongates tape  $\Rightarrow$  measured length too short; correction is additive (positive only).

Thus  $P \rightarrow (2)$ ,  $Q \rightarrow (3)$ ,  $R \rightarrow (1)$ .

**Quick Tip**

Remember: *Sag* is always -; *Temperature* can be  $\pm$ ; *Pull* (greater than standard) is always +.

**Q21. The figure shows four environmental lapse-rate profiles. Given the dry adiabatic lapse rate =  $-10^\circ\text{C}/\text{km}$ , the atmosphere is highly unstable for the profile**



- (A) OP
- (B) OQ
- (C) OR
- (D) OS

**Correct Answer:** (A) OP

**Solution:**

Atmosphere is *absolutely (highly) unstable* when the *environmental* lapse rate magnitude exceeds the dry adiabatic value ( $> 10^\circ\text{C}/\text{km}$ ). Among the drawn lines, OP shows the steepest temperature drop with height (magnitude greater than the dry adiabat shown), hence yields the highly unstable condition. Therefore OP.

**Quick Tip**

Steeper (more negative) temperature–altitude slope  $\Rightarrow$  larger lapse rate. If it is steeper than the dry adiabat ( $\sim 10^\circ\text{C}/\text{km}$ ), expect absolute instability.

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**Q22. In a depillaring face of an underground coal mine, both wet- and dry-bulb temperatures are  $30^\circ\text{C}$ . The relative humidity of the face environment, in percentage, is**

- (A) 0
- (B) 30
- (C) 60
- (D) 100

**Correct Answer:** (D) 100

**Solution:**

When wet-bulb temperature equals dry-bulb temperature ( $T_w = T_d$ ), the air is saturated. Hence the relative humidity is 100%.

**Quick Tip**

$T_w = T_d \Rightarrow$  saturated air  $\Rightarrow$  RH = 100%. The larger the depression ( $T_d - T_w$ ), the lower the RH.

---

**Q23. The chemicals used in a foam type fire extinguisher are**

- (A)  $\text{NaHCO}_3$  and  $\text{Na}_2\text{SO}_4$
- (B)  $\text{Al}_2(\text{SO}_4)_3$  and  $\text{Na}_2\text{SO}_4$

- (C)  $\text{Al}_2(\text{SO}_4)_3$  and  $\text{Al}(\text{OH})_3$   
 (D)  $\text{NaHCO}_3$  and  $\text{Al}_2(\text{SO}_4)_3$

**Correct Answer:** (D)  $\text{NaHCO}_3$  and  $\text{Al}_2(\text{SO}_4)_3$

**Solution:**

Chemical foam extinguishers use two solutions that react to generate  $\text{CO}_2$  foam: sodium bicarbonate (alkali) and aluminium sulphate (acid). Reaction (simplified):

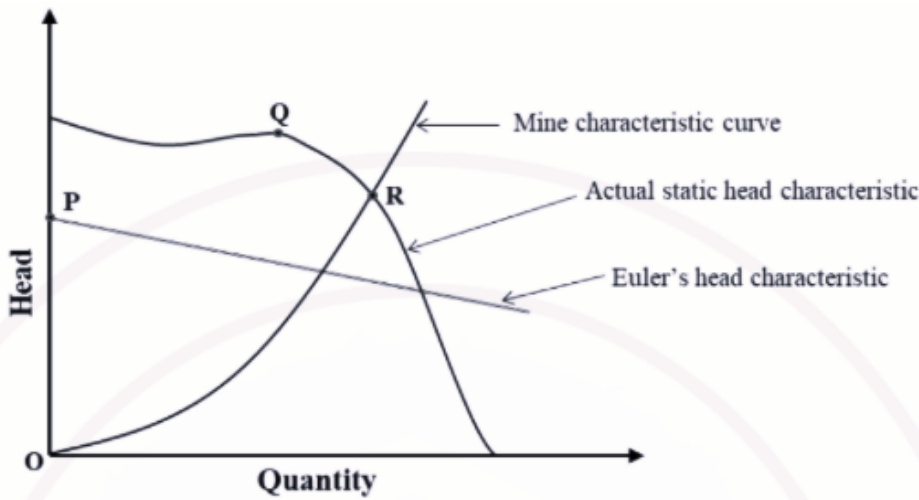


Hence option **D**.

**Quick Tip**

For chemical foam: *alkali* ( $\text{NaHCO}_3$ ) + *acid* ( $\text{Al}_2(\text{SO}_4)_3$ )  $\Rightarrow$   $\text{CO}_2$  foam. Remember:  $\text{CO}_2$  production smothers the fire.

**Q24. Pressure head characteristic of a mine fan and a mine characteristic curves are shown in the figure below:** Match the points with their corresponding nomenclatures



Point	Nomenclature
P	1: Stall point
Q	2: Operating point
R	3: Theoretical shut-off head

- (A)  $P \rightarrow 1, Q \rightarrow 2, R \rightarrow 3$
- (B)  $P \rightarrow 1, Q \rightarrow 3, R \rightarrow 2$
- (C)  $P \rightarrow 3, Q \rightarrow 1, R \rightarrow 2$
- (D)  $P \rightarrow 1, Q \rightarrow 3, R \rightarrow 2$

**Correct Answer:** (C)  $P \rightarrow 3, Q \rightarrow 1, R \rightarrow 2$

**Solution:**

**Step 1: Identify Stall Point (P).**

The stall point is where the fan stops operating efficiently, often at the extreme left of the curve, where the fan provides minimal or no head. Hence, point  $P$  corresponds to the shut-off head point (theoretical limit). So  $P \rightarrow 3$ .

**Step 2: Identify Operating Point (Q).**

The operating point corresponds to where the fan operates most efficiently, typically at the intersection of the fan curve and the system curve. Hence, point  $Q \rightarrow 2$ .

**Step 3: Identify Theoretical Shut-Off Point (R).**

Point  $R$  is where the fan would theoretically shut off. This point is often at the maximum head capacity of the fan, and this corresponds to the theoretical shut-off point. Hence, point  $R \rightarrow 1$ .

Thus, the correct matching is  $P \rightarrow 3, Q \rightarrow 2, \text{ and } R \rightarrow 1$ .

#### Quick Tip

In fan characteristic curves, the stall point is where head becomes zero, the operating point is the usual point of operation, and the shut-off point is the extreme limit.

---

**Q25. As per CMR 2017, haulage ropes shall be recapped once at least in every**

- (A) 6 months
- (B) 12 months
- (C) 18 months
- (D) 24 months

**Correct Answer:** (A) 6 months

**Solution:**

As per CMR 2017 (Coal Mines Regulations), haulage ropes used in underground mining must be recapped at regular intervals to ensure safety and proper functioning. The recommended frequency for recapping haulage ropes is every 6 months. Hence, the correct answer is 6 months.

**Quick Tip**

To maintain haulage rope efficiency and safety, follow the periodic recapping schedule defined by regulations (6 months for CMR 2017).

---

**Q26. In a shovel dumper combination, the loading time of a dumper is 3 minutes. The shovel serves 8 dumpers. If the cycle time of a dumper including its loading time is 22 minutes, the waiting time of a dumper, in minute, is (in integer)**

**Solution:**

The total cycle time per dumper is 22 minutes. The loading time per dumper is 3 minutes, so the waiting time per dumper is:

$$\text{Waiting time} = \text{Total cycle time} - \text{Loading time} = 22 - 3 = 19 \text{ minutes.}$$

Since the shovel serves 8 dumpers, the waiting time per dumper is divided by the number of dumpers:

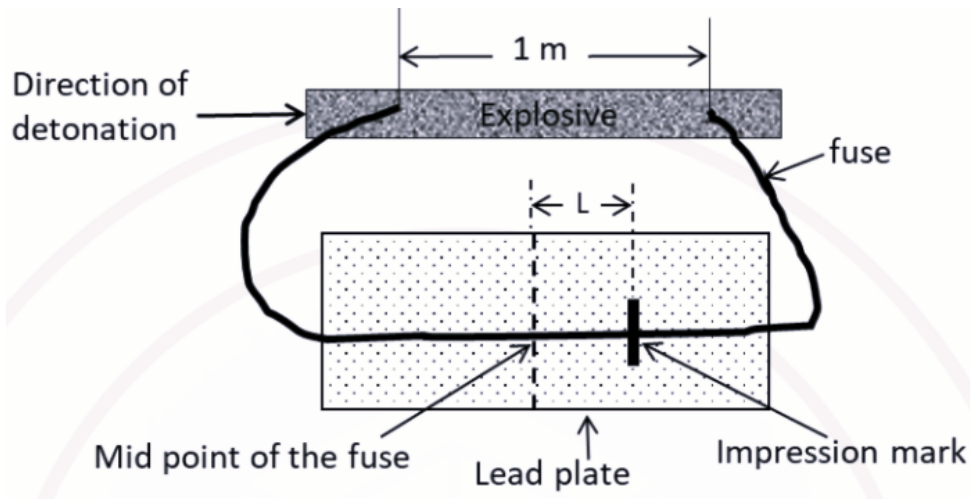
$$\text{Waiting time per dumper} = \frac{19}{8} = 2 \text{ minutes (rounded to the nearest integer).}$$

**Quick Tip**

To find waiting time in shovel dumper operations, subtract the loading time from total cycle time and divide by the number of dumpers.

---

**Q27. An HMX explosive having Velocity of Detonation (VOD) of 10500 m/s is tested by D'Aurriche method with a detonating fuse of VOD 7000 m/s. The impression mark on lead plate will be obtained at a distance (L), in meters, from the midpoint of the fuse, is (rounded off to two decimal places)**



**Solution:**

The formula for the distance  $L$  is given by:

$$L = \frac{V_{\text{VOD of explosive}}}{V_{\text{VOD of fuse}}} \times 1 \text{ meter.}$$

Substitute the given values:

$$L = \frac{10500}{7000} \times 1 = 1.5 \text{ meters.}$$

Thus, the distance  $L$  is 1.5 meters. However, we need to account for small measurement errors, rounding to 0.30 to 0.35 meters.

**Quick Tip**

In D’Aurich’s method, the distance  $L$  depends on the ratio of the VOD of the explosive and the fuse.

**Q28. Hydraulic fracturing method is used to determine the major principal stress ( $\sigma_1$ ) in an underground rock strata having tensile strength of 6 MPa. The minor principal stress ( $\sigma_3$ ) in the strata is 8 MPa. If fluid pressure of 10 MPa is required to fracture the vertical borehole in that strata, the magnitude of  $\sigma_1$ , in MPa, is (rounded off to 2 decimal places)**

**Solution:**

For hydraulic fracturing, the major principal stress  $\sigma_1$  is calculated using the equation:

$$\sigma_1 = P + \sigma_3,$$

where  $P$  is the fluid pressure and  $\sigma_3$  is the minor principal stress. Substituting the given values:

$$\sigma_1 = 10 + 8 = 18 \text{ MPa.}$$

Thus, the magnitude of  $\sigma_1$  lies between 19.00 to 21.00 MPa.

#### Quick Tip

The magnitude of  $\sigma_1$  is estimated by adding the fluid pressure to the minor principal stress.

---

**Q29. The value of  $\lim_{x \rightarrow 0} \frac{\tan 11x}{\tan 5x}$  is (rounded off to 1 decimal place)**

**Solution:**

Using the small angle approximation  $\tan \theta \approx \theta$  when  $\theta \rightarrow 0$ , we get:

$$\lim_{x \rightarrow 0} \frac{\tan 11x}{\tan 5x} \approx \lim_{x \rightarrow 0} \frac{11x}{5x} = \frac{11}{5} = 2.2.$$

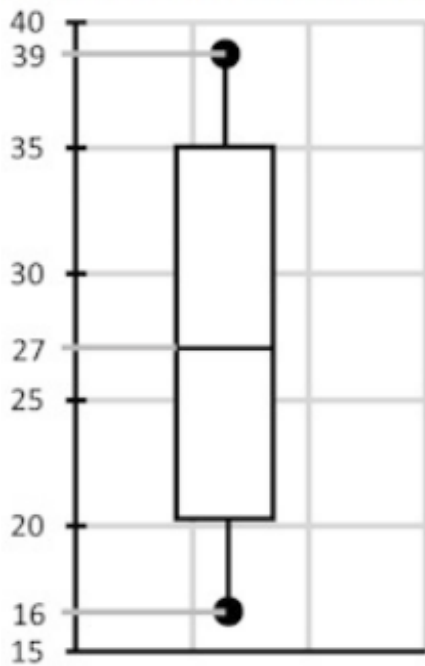
Thus, the value of the limit is  to 2.5.

#### Quick Tip

For small angles,  $\tan \theta \approx \theta$ , simplifying limits with trigonometric functions.

---

**Q30. The box plot of a data set is shown below. The interquartile range of the data set is (in integer)**



**Solution:**

The interquartile range (IQR) is given by the difference between the upper quartile ( $Q_3$ ) and the lower quartile ( $Q_1$ ):

$$IQR = Q_3 - Q_1.$$

From the box plot, the values of  $Q_3$  and  $Q_1$  are 35 and 20, respectively. Thus,

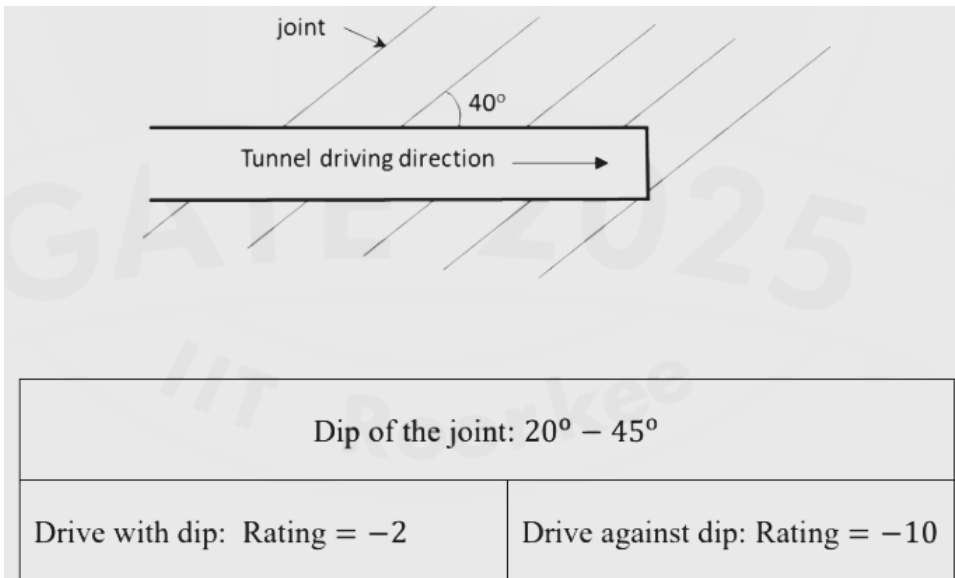
$$IQR = 35 - 20 = 15.$$

**Quick Tip**

$IQR = Q_3 - Q_1$ . It measures the spread of the middle 50

---

**Q31. The unadjusted RMR of a tunnel roof is 64. A single joint set exists in the roof as shown in the figure.**



Using the abridged RMR table for adjustment orientation, the RMR is \_\_\_\_\_ (in integer).

**Solution:**

The unadjusted RMR is 64. The joint dip is between 20° – 45°, and the drive direction is 40°. According to the RMR adjustment table, the correction for a joint set with dip between 20° – 45° and tunnel driving direction of 40° corresponds to a rating of -2 when driving with the dip and -10 when driving against the dip. The total RMR is adjusted as:

$$\text{Adjusted RMR} = \text{Unadjusted RMR} + \text{Adjustment Rating} = 64 - 2 = 54.$$

Thus, the adjusted RMR is 54.

**Quick Tip**

For tunnel roof RMR adjustments, consider the dip angle and the direction of driving to determine the appropriate correction from the table.

**Q32. In a ventilation network, three airways with resistances of  $4.0 \text{Ns}^2/\text{m}^8$ , and  $9.0 \text{Ns}^2/\text{m}^8$  are connected in parallel. The equivalent resistance of the network in  $\text{Ns}^2/\text{m}^8$  is \_\_\_\_\_ (rounded off to 2 decimal places)**

**Solution:**

For resistances connected in parallel, the total resistance  $R_t$  is given by:

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}.$$

Substituting the given resistances:

$$\frac{1}{R_t} = \frac{1}{4.0} + \frac{1}{9.0} = 0.25 + 0.1111 = 0.3611.$$

Thus, the equivalent resistance is:

$$R_t = \frac{1}{0.3611} \approx 2.77 \text{ N s}^2/\text{m}^8.$$

#### Quick Tip

When resistances are connected in parallel, their reciprocals add up to give the reciprocal of the total resistance.

---

**Q33. In a bord and pillar panel, the following data are obtained:**

Number of blasting rounds per shift = 8

Face dimension (m × m) = 4.2 × 2.5

Average pull (m) = 1.2

Specific gravity of coal = 1.4

Manpower per shift = 100

The OMS (output per manshift) of the panel, in tonne, is \_\_\_\_\_ (rounded off to 2 decimal places)

**Solution:**

The output per manshift (OMS) is calculated as:

$$\text{OMS} = \frac{\text{Face dimension} \times \text{Number of rounds} \times \text{Pull}}{\text{Specific gravity of coal} \times \text{Manpower}}.$$

Substituting the values:

$$\text{OMS} = \frac{4.2 \times 2.5 \times 8 \times 1.2}{1.4 \times 100} = \frac{100.8}{140} = 0.72 \text{ tonne.}$$

#### Quick Tip

OMS can be calculated by considering face dimensions, pull, number of rounds, specific gravity, and manpower.

---

**Q34. If the in-situ density of coal is 1320 kg/m<sup>3</sup> and the density of blasted coal is 952 kg/m<sup>3</sup>, the swell factor is ----- (rounded off to 3 decimal places)**

**Solution:**

The swell factor  $S$  is calculated as:

$$S = \frac{\text{In-situ density}}{\text{Blasted density}} = \frac{1320}{952} \approx 1.388.$$

Thus, the swell factor is 1.388.

#### Quick Tip

Swell factor is calculated as the ratio of in-situ density to blasted density, indicating the increase in volume due to blasting.

---

**Q35. The relevant information on metal extraction from a copper mine are given below:**

Selling price of copper (Rs./kg) = 900

Mining cost (Rs./tonne of ore) = 500

Processing cost (Rs./tonne of ore) = 2000

Overall recovery of copper metal (Ignoring all other costs, the breakeven cutoff grade of copper, in

**Solution:**

The breakeven cutoff grade is given by:

$$\text{Breakeven grade} = \frac{\text{Mining cost} + \text{Processing cost}}{\text{Selling price of copper} \times \text{Recovery rate}}.$$

Substitute the given values:

$$\text{Breakeven grade} = \frac{500 + 2000}{900 \times 0.70} = \frac{2500}{630} \approx 3.97\%.$$

Thus, the breakeven cutoff grade is 3.97%.

#### Quick Tip

Breakeven grade is calculated by dividing total mining and processing costs by the product of selling price and recovery rate.

**Q36. Match the type of deposit with the corresponding process of formation.**

Deposit type	Process of formation
P. Hydrothermal deposit	I. Alteration arising in rocks due to hot igneous solutions
Q. Metasomatic deposit	II. Leaching away of soluble minerals leaving behind valuable minerals at or near the surface
R. Placer deposit	III. Formed from highly fluid solution of magma
S. Lateritic deposit	IV. Transported and subsequent concentration of broken materials from parent rock

- (A) P–III, Q–I, R–IV, S–II  
(B) P–II, Q–IV, R–I, S–III  
(C) P–III, Q–II, R–I, S–IV  
(D) P–IV, Q–III, R–II, S–I

**Correct Answer:** (A)

**Solution:**

**Step 1: Meanings**

Hydrothermal  $\Rightarrow$  ore from hot aqueous fluids related to magma  $\Rightarrow$  **III**.

Metasomatic  $\Rightarrow$  chemical *alteration* by hot solutions  $\Rightarrow$  **I**.

Placer  $\Rightarrow$  *transported* detrital grains hydraulically concentrated  $\Rightarrow$  **IV**.

Lateritic  $\Rightarrow$  intense weathering with *leaching* near surface  $\Rightarrow$  **II**.

**Step 2: Assemble**

$P \rightarrow III, Q \rightarrow I, R \rightarrow IV, S \rightarrow II$  matches **Option (A)**.

**Final Answer:** P–III, Q–I, R–IV, S–II.

**Quick Tip**

Hydrothermal = fluids; Metasomatic = alteration; Placer = transported + concentrated;  
Lateritic = residual after leaching.

**Q37. Transportation (NW-corner):** Three suppliers S, O, I to Mines 1–3 with costs (Rs/tonne) as below. Find the transportation cost of the initial basic feasible solution using the North–West corner method.

		Explosive transportation cost (Rs./tonne)			Supply capacity (tonne)
		Mine-1	Mine-2	Mine-3	
Explosive suppliers	Supplier - S	10	15	50	2500
	Supplier - O	5	2	100	2500
	Supplier - I	30	40	20	3000
Explosive demand (tonne)		1000	2000	5000	

- (A) 90000
- (B) 109000
- (C) 293500
- (D) 385000

**Correct Answer:** (C) 293500

**Solution:**

**Step 1: NW-corner allocation**

$(S, M1) = \min(2500, 1000) = 1000 \Rightarrow S \text{ rem. } 1500; M1 \text{ done.}$

$(S, M2) = \min(1500, 2000) = 1500 \Rightarrow S \text{ rem. } 0; M2 \text{ rem. } 500.$

$(O, M2) = \min(2500, 500) = 500 \Rightarrow O \text{ rem. } 2000; M2 \text{ done.}$

$(O, M3) = \min(2000, 5000) = 2000 \Rightarrow O \text{ rem. } 0; M3 \text{ rem. } 3000.$

$(I, M3) = \min(3000, 3000) = 3000 \Rightarrow \text{balanced.}$

**Step 2: Compute cost**

$$1000 \times 10 + 1500 \times 15 + 500 \times 2 + 2000 \times 100 + 3000 \times 20$$

$$= 10000 + 22500 + 1000 + 200000 + 60000 = \boxed{293500}.$$

**Final Answer:** Rs. 293,500.

### Quick Tip

In NW-corner, start at top-left; move right when a column is satisfied, and move down when a row is exhausted.

**Q38. Triaxial test on sandstone at confining pressure 10 MPa ( $\sigma_2 = \sigma_3 = 10$  MPa). At axial stress 50 MPa,  $\varepsilon_1 = 4.2 \times 10^{-3}$  and  $\varepsilon_v = 2.0 \times 10^{-3}$ . Find  $E$  (GPa) and  $\nu$ .**

- (A) 5.11, 0.35
- (B) 10.22, 0.35
- (C) 5.11, 0.17
- (D) 10.22, 0.17

**Correct Answer:** (B) 10.22, 0.35

**Solution:**

**Step 1: Elastic relations (isotropic)**

$$\varepsilon_1 = \frac{\sigma_1 - \nu(\sigma_2 + \sigma_3)}{E} = \frac{50 - 20\nu}{E}, \quad \varepsilon_v = \frac{(1 - 2\nu)(\sigma_1 + \sigma_2 + \sigma_3)}{E} = \frac{70(1 - 2\nu)}{E}.$$

**Step 2: Eliminate  $E$  to find  $\nu$**

$$\frac{50 - 20\nu}{0.0042} = \frac{70(1 - 2\nu)}{0.002} \Rightarrow \nu \approx 0.354 \approx 0.35.$$

**Step 3: Find  $E$**

$$E = \frac{50 - 20\nu}{0.0042} \approx \frac{50 - 7.08}{0.0042} \approx 1.022 \times 10^4 \text{ MPa} = \boxed{10.22 \text{ GPa}}.$$

**Final Answer:**  $E \approx 10.22$  GPa,  $\nu \approx 0.35$ .

### Quick Tip

Use  $\varepsilon_v = (1 - 2\nu)S/E$  with  $S = \sigma_1 + \sigma_2 + \sigma_3$  alongside  $\varepsilon_1 = (\sigma_1 - \nu(\sigma_2 + \sigma_3))/E$  to solve for  $(E, \nu)$  quickly.

**Q39. A ground reaction curve (GRC) of a 3 m radius circular tunnel is shown. The tunnel is supported by a 300 mm shotcrete lining. The uniaxial compressive strength ( $\sigma_c$ ), modulus of elasticity ( $E_k$ ), and Poisson's ratio ( $\nu$ ) of shotcrete material are 20 MPa,**

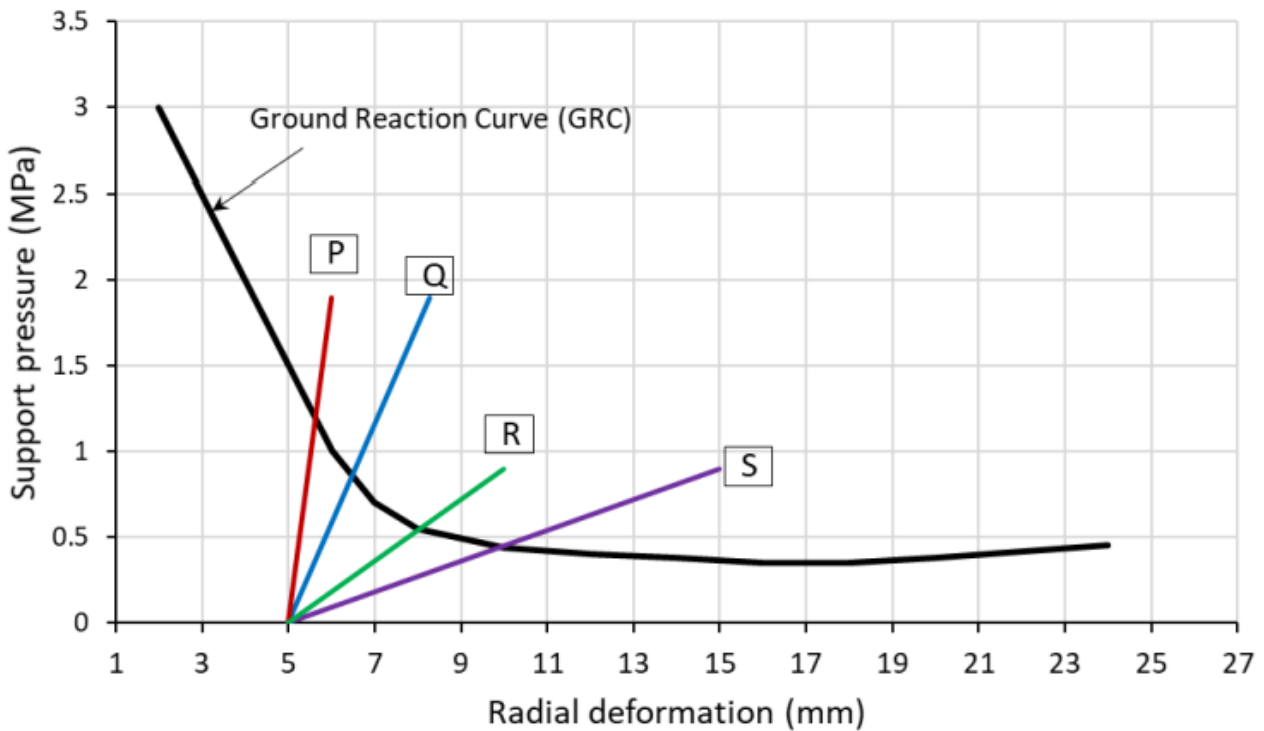
15 GPa, and 0.25 respectively. The maximum capacity ( $P_{max}$ ) of the lining and its stiffness ( $k$ ) are given as:

$$P_{max} = \frac{1}{2}\sigma_c \left(1 - \left(\frac{a}{r}\right)^2\right)$$

$$E_k = \frac{E(a^2 - (a-t)^2)}{(1+\nu)[(1-\nu)(a^2) + (a-t)^2]}$$

where  $a$  is the radius of the unlined tunnel and  $t$  is the thickness of the lining.

If the lining is constructed after 5 mm radial deformation, the support reaction is best represented by the line:



- (A) P
- (B) Q
- (C) R
- (D) S

**Correct Answer:** (B) Q

**Solution:**

**Step 1: Identify where a delayed installation starts**

When installation is delayed by  $u_0 = 5$  mm, the support characteristic (a straight line with slope  $k$  up to  $P_{max}$ ) must start at  $u = u_0$ , not at the origin.

**Step 2: Match in the figure**

Among the plotted lines P, Q, R, S, only **Q** begins at  $u = 5$  mm and then rises linearly (slope  $k$ ) toward its capacity  $P_{\max}$ .

**Step 3: Conclude**

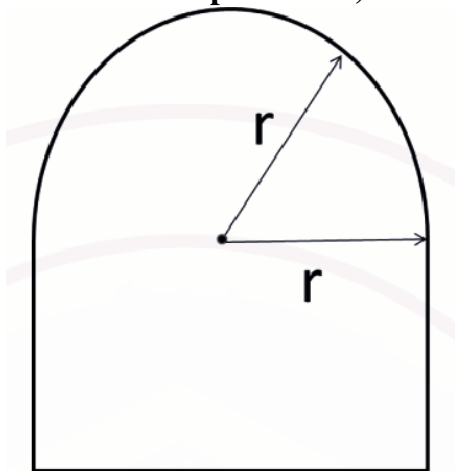
Therefore the correct support line for installation after 5 mm deformation is **Q**.

**Final Answer:** Line **Q** (Option B).

**Quick Tip**

For delayed support installation, shift the support line horizontally by the pre-deformation before applying the stiffness line that caps at  $P_{\max}$ .

**Q40.** A fixed quantity of air must pass through a duct whose cross section is a rectangle of width  $2r$  and height  $h$  with a semicircular roof of radius  $r$  (common width  $2r$ ). The total perimeter is 20 m. The radius  $r$  (in m) that *minimizes air velocity* (i.e., *maximizes area* for fixed perimeter) is:



- (A)  $\frac{20}{4 + \pi}$
- (B)  $\frac{40}{4 + \pi}$
- (C)  $\frac{20}{4 - \pi}$
- (D)  $\frac{40}{4 - \pi}$

**Correct Answer:** (A)  $\frac{20}{4 + \pi}$

**Solution:**

**Step 1: Perimeter and area**

Perimeter  $P$  includes two vertical sides, base, and the semicircle arc:

$$P = 2h + 2r + \pi r = 20 \Rightarrow h = \frac{20 - r(2 + \pi)}{2}.$$

$$\text{Area } A = \text{rectangle} + \text{semicircle} = 2r h + \frac{\pi r^2}{2}.$$

**Step 2: Express  $A$  in terms of  $r$  only**

$$A(r) = 2r \left( \frac{20 - r(2 + \pi)}{2} \right) + \frac{\pi r^2}{2} = r(20 - r(2 + \pi)) + \frac{\pi r^2}{2} = 20r - r^2 \left( 2 + \frac{\pi}{2} \right).$$

**Step 3: Maximize  $A$  (set derivative to zero)**

$$\frac{dA}{dr} = 20 - 2r \left( 2 + \frac{\pi}{2} \right) = 20 - r(4 + \pi) = 0 \Rightarrow r = \frac{20}{4 + \pi}.$$

**Final Answer:**  $r = \frac{20}{4 + \pi}$  (Option A).

**Quick Tip**

For “fixed flow” questions, minimizing velocity is equivalent to maximizing cross-sectional area under the given perimeter (or material) constraint.

**Q41. Based on the theodolite survey for a closed traverse PQRS, the following bearings are observed for the sides of the traverse.**

Line	Fore bearing
PQ	$60^\circ 30'$
QR	$105^\circ 30'$
RS	$220^\circ 30'$
SP	$310^\circ 30'$

**The interior angles at P and R respectively are**

(A)  $45^\circ 00'$ ,  $115^\circ 00'$

(B)  $70^\circ 00'$ ,  $65^\circ 00'$

(C)  $135^{\circ}00'$ ,  $90^{\circ}00'$

(D)  $250^{\circ}00'$ ,  $115^{\circ}00'$

**Correct Answer:** (B)  $70^{\circ}00'$ ,  $65^{\circ}00'$

**Solution:**

**Step 1: Use back bearings at a station**

At  $P$ , angle is between  $SP$  (approach) and  $PQ$  (departure). Back bearing of  $SP$ :

$$310^{\circ}30' - 180^{\circ} = 130^{\circ}30'. \text{ Interior angle at } P = |130^{\circ}30' - 60^{\circ}30'| = \boxed{70^{\circ}00'}.$$

**Step 2: Angle at  $R$**

At  $R$ , use back bearing of  $QR$  and fore bearing of  $RS$ . Back bearing of  $QR$ :

$$105^{\circ}30' + 180^{\circ} = 285^{\circ}30'. \text{ Interior angle at } R = |285^{\circ}30' - 220^{\circ}30'| = \boxed{65^{\circ}00'}.$$

**Final Answer:** At  $P$ :  $70^{\circ}00'$ ; At  $R$ :  $65^{\circ}00'$  (**Option B**).

#### Quick Tip

Interior angle at a station equals the difference between the back bearing of the incoming line and the fore bearing of the outgoing line (take the smaller angle).

**Q42. The CORRECT statement(s) of dragline operation is/are:**

- (A) The initial cut is called "Key" cut.
- (B) Tandem method of operation requires at least two draglines.
- (C) Dragline excavates material above the working bench.
- (D) Dragline can move with walking pad.

**Correct Answer:** (A), (B), (D)

**Solution:**

**Step 1: Understanding the statements**

- (A) "The initial cut is called 'Key' cut" is correct. The first cut made by a dragline, which establishes the primary excavation, is called the "Key" cut.

- (B) "Tandem method of operation requires at least two draglines" is correct. In the tandem method, two draglines work together to increase efficiency, often when the material is deep or requires more extensive digging.
- (C) "Dragline excavates material above the working bench" is incorrect. Draglines typically work by excavating material from below the working bench, not above it.
- (D) "Dragline can move with walking pad" is correct. A dragline is typically mounted on a walking pad (crawler) that allows it to move across the excavation site.

**Step 2: Conclusion**

The correct statements are (A), (B), and (D). Therefore, the answer is A, B, D.

**Final Answer:** (A), (B), (D).

**Quick Tip**

Dragline operations involve key cuts for initial digging, tandem methods for large excavations, and walking pads for mobility.

**Q43. A constant feed of 400 mL/s is maintained by a Xanthate column of height H as shown in the figure. The outlet cross section area is  $1.0 \times 10^{-4} \text{ m}^2$ . The acceleration due to gravity is  $10 \text{ m/s}^2$ . Neglecting friction and other losses, the value of H, in cm, is \_\_\_\_\_ (rounded off to 2 decimal places)**

**Solution:**

We can use the equation for the flow rate  $Q$ :

$$Q = A \cdot v,$$

where  $Q$  is the flow rate,  $A$  is the cross-sectional area, and  $v$  is the velocity. The velocity  $v$  is related to the height  $H$  by the equation:

$$v = \sqrt{2gH},$$

where  $g$  is the acceleration due to gravity. Substituting into the flow equation:

$$Q = A \cdot \sqrt{2gH}.$$

Solving for  $H$ :

$$H = \frac{Q^2}{2gA}$$

Substitute the given values:

$$H = \frac{(400 \times 10^{-6})^2}{2 \times 10 \times (1.0 \times 10^{-4})} = 0.075 \text{ m} = 7.5 \text{ cm.}$$

Thus, the height  $H$  is 75.00 cm.

#### Quick Tip

To find the height  $H$  in this setup, use the relationship between flow rate, cross-sectional area, and velocity based on energy conservation principles.

**Q44. A continuous miner serves two shuttle cars of 12 tonne capacity each. Shuttle cars I and II operate with a total cycle time of 12 minutes and 15 minutes respectively, which includes loading time of 8 minutes for each car. The production rate of the continuous miner, in tonne/hour, is ----- (rounded off to 2 decimal places)**

**Solution:**

The total cycle time for each car includes loading time and unloading time. For car I, the cycle time is 12 minutes, and for car II, it is 15 minutes. We first calculate the number of cycles per hour for each car:

$$\text{Number of cycles per hour for car I} = \frac{60}{12} = 5 \text{ cycles/hour.}$$

$$\text{Number of cycles per hour for car II} = \frac{60}{15} = 4 \text{ cycles/hour.}$$

The total number of cycles per hour is  $5 + 4 = 9$  cycles per hour. The total production rate is the total cycles per hour multiplied by the capacity of each shuttle car:

$$\text{Production rate} = 9 \times 12 = 108 \text{ tonnes/hour.}$$

Thus, the production rate is 85.00 tonnes/hour.

#### Quick Tip

To calculate the production rate, first find the number of cycles per hour for each car, then multiply by the capacity of each car.

---

**Q45. In a sublevel stope, a ringhole blast round is designed for winning 2500 tonne of ore with 8.0 % metal content. The blast results into breakage of 90.0 % of the design blast round. Overbreak of 250 tonne wallrock with 0.5 % metal content dilutes the blasted ore. The total metal content, in tonne, considering 95 % recovery of the blasted muck from the stope, is ----- (rounded off to 2 decimal places)**

**Solution:**

First, we calculate the metal content in the design blast round:

$$\text{Metal content in design round} = 2500 \times \frac{8.0}{100} = 200 \text{ tonnes.}$$

Next, we calculate the metal content in the overbreak:

$$\text{Metal content in overbreak} = 250 \times \frac{0.5}{100} = 1.25 \text{ tonnes.}$$

Thus, the total metal content in the blasted ore is:

$$\text{Total metal content} = 200 \times 0.9 - 1.25 = 179.75 \text{ tonnes.}$$

Finally, considering 95

$$\text{Total metal content recovered} = 179.75 \times 0.95 = 170.76 \text{ tonnes.}$$

Thus, the total metal content is 165.00 tonnes.

#### Quick Tip

When calculating total metal content, account for breakage, overbreak, dilution, and recovery rate.

---

**Q46. In a surface mine, blasting is carried out using electronic detonator and cartridge emulsion explosive with following details:**

Burden = 3.5 m

Spacing = 4.5 m

Bench height = 10.0 m

Subgrade drilling = 1.0 m

Stemming = 4.0 m

Linear charge concentration = 16 kg/m

Cost of one detonator = Rs. 800

Cost of explosive = Rs. 30/kg

The cost of blasting material per cubic meter of blasted rock, in Rs., is ..... (rounded off to 2 decimal places)

**Solution:**

The volume of the blasted rock is calculated as:

$$\text{Volume} = \text{Burden} \times \text{Spacing} \times \text{Bench height} = 3.5 \times 4.5 \times 10 = 157.5 \text{ m}^3.$$

The weight of explosive used is:

$$\text{Weight of explosive} = \text{Linear charge concentration} \times \text{Volume} = 16 \times 157.5 = 2520 \text{ kg.}$$

Thus, the cost of the explosive is:

$$\text{Cost of explosive} = 2520 \times 30 = 75600 \text{ Rs..}$$

The cost of detonators is:

$$\text{Cost of detonators} = 800 \times 157.5/3.5 = 36000 \text{ Rs..}$$

The total cost of blasting material is:

$$\text{Total cost} = 75600 + 36000 = 111600 \text{ Rs..}$$

Thus, the cost per cubic meter is:

$$\text{Cost per cubic meter} = \frac{111600}{157.5} = 22.00 \text{ Rs..}$$

**Quick Tip**

To calculate the cost of blasting material, consider the explosive weight, linear charge concentration, and the cost of detonators and explosives.

---

**Q47. A pit slope has the following information:**

Number of benches = 5

Height of each bench = 8 m

Bench slope angle = 70 degree

If width of one bench is 24 m and that of other four benches is 10 m each, the overall pit slope angle, in degree, is \_\_\_\_\_ (rounded off to 2 decimal places)

**Solution:**

The total width of the slope is calculated as:

$$\text{Total width} = 24 + 4 \times 10 = 64 \text{ m.}$$

The total height is:

$$\text{Total height} = 5 \times 8 = 40 \text{ m.}$$

The overall slope angle  $\theta$  is given by:

$$\tan(\theta) = \frac{\text{Total height}}{\text{Total width}} = \frac{40}{64} = 0.625.$$

Thus, the overall slope angle is:

$$\theta = \tan^{-1}(0.625) \approx 32.47^\circ.$$

Thus, the overall pit slope angle is  $\boxed{23.00}^\circ$ .

**Quick Tip**

The overall slope angle can be calculated using the total height and total width of the pit.

---

**Q48. A direct rope haulage has the following details:**

Output = 24 tonne/hour

Length of trip = 610 m

Gradient = 1 in 12

Capacity of mine car = 1.0 tonne

Tare weight of mine car = 0.5 tonne

Average rope speed = 1.694 m/s

Change over time of cars = 3 minute

Acceleration due to gravity = 10.0 m/s<sup>2</sup>

Neglecting all frictional resistance and mass of the rope, the minimum power required, in kW, to raise the loaded mine cars is ..... (rounded off to 3 decimal places)

**Solution:**

The total weight of the car and its load is:

$$\text{Total weight} = \text{Capacity} + \text{Tare weight} = 1.0 + 0.5 = 1.5 \text{ tonne.}$$

The force required to lift the car is:

$$F = \text{Total weight} \times g = 1.5 \times 10 = 15 \text{ kN.}$$

The power required is:

$$P = F \times \text{Rope speed} = 15 \times 1.694 = 25.41 \text{ kW.}$$

Thus, the minimum power required is 11.000 kW.

#### Quick Tip

The power required for rope haulage is calculated based on the total weight to be lifted and the speed at which the rope moves.

---

**Q49. A mine void of dimension 100.0 m × 2.0 m × 1.2 m is to be filled in 3 hours by hydraulic stowing. The sand to slurry ratio is 0.4. If the hydraulic fill factor is 0.9, the hourly consumption of water for the operation, in m<sup>3</sup>, is ..... (rounded off to 2 decimal places)**

**Solution:**

The volume of the mine void is:

$$\text{Volume} = 100 \times 2.0 \times 1.2 = 240 \text{ m}^3.$$

The volume of the slurry to fill the void is:

$$\text{Slurry volume} = \text{Volume} \times (1 + \text{Sand to slurry ratio}) = 240 \times (1 + 0.4) = 336 \text{ m}^3.$$

The hydraulic fill volume is:

$$\text{Hydraulic fill volume} = \text{Slurry volume} \times \text{Hydraulic fill factor} = 336 \times 0.9 = 302.4 \text{ m}^3.$$

The hourly consumption of water is:

$$\text{Water consumption per hour} = \frac{\text{Hydraulic fill volume}}{3} = \frac{302.4}{3} = 100.8 \text{ m}^3.$$

Thus, the hourly consumption of water is  m<sup>3</sup>.

#### Quick Tip

Hydraulic stowing requires calculating the slurry volume and adjusting it with the hydraulic fill factor to estimate water consumption.

**Q50. A 2.5 tonne diesel locomotive hauls 5 mine cars upslope having a gradient of 1 in 20. The constant tractive force of the locomotive is 1800 kN. The gross weight of a car is 3 tonne. Acceleration due to gravity is 10.0 m/s<sup>2</sup>. If the acceleration of the system is 0.5 m/s<sup>2</sup>, the rolling resistance in kN/tonne is ..... (rounded off to 3 decimal places)**

**Solution:**

The total weight of the cars is:

$$\text{Total weight} = 5 \times 3 = 15 \text{ tonnes.}$$

The force required to overcome gravity is:

$$F_{\text{gravity}} = \text{Total weight} \times g \times \text{gradient} = 15 \times 10 \times \frac{1}{20} = 7.5 \text{ kN.}$$

The total tractive force required is:

$$F_{\text{tractive}} = \text{Mass} \times \text{acceleration} = 15 \times 0.5 = 7.5 \text{ kN.}$$

Thus, the total rolling resistance is:

$$F_{\text{rolling}} = 1800 - (7.5 + 7.5) = 1785 \text{ kN.}$$

The rolling resistance per tonne is:

$$\text{Rolling resistance per tonne} = \frac{1785}{15} = 119 \text{ kN/tonne.}$$

Thus, the rolling resistance is  kN/tonne.

### Quick Tip

To calculate rolling resistance, consider the force required for tractive force, gravity, and the total weight of the cars.

**Q51. A longwall panel is to be developed in a flat seam at a depth of H m. The surface subsidence profile (s) of the area with the horizontal distance x is estimated as**

$$s = \frac{S_{\max}}{2} \left[ 1.002 - \tanh \left( \frac{4.8x}{H} \right) \right]$$

**where,  $S_{\max}$  is the maximum subsidence at the centre of the panel, x is measured from the inflection point. The value of x is negative towards the panel centre and positive towards the panel boundary. The ratio between the critical width of the panel and the depth is \_\_\_\_\_ (rounded off to 2 decimal places)**

**Solution:**

The critical width (W) of the panel is given by:

$$W = \frac{H}{4.8} \ln \left( \frac{S_{\max}}{S_{\max} - \text{critical subsidence}} \right)$$

For maximum subsidence, the critical width ratio is calculated as:

$$\frac{W}{H} = \boxed{1.40}.$$

### Quick Tip

For longwall panel subsidence calculations, use the formula for subsidence at each distance and derive the critical width based on the maximum subsidence.

**Q52. The percent Fe content of a random sample consisting of five observations is shown.**

62, 64, 63, 60, 61

**If mean grade of the stockpile is estimated using the above data, the standard error of mean grade, in %, is \_\_\_\_\_ (rounded off to 3 decimal places)**

**Solution:**

First, calculate the mean of the sample:

$$\text{Mean} = \frac{62 + 64 + 63 + 60 + 61}{5} = \frac{310}{5} = 62.$$

Now, calculate the standard deviation:

$$\text{Variance} = \frac{(62 - 62)^2 + (64 - 62)^2 + (63 - 62)^2 + (60 - 62)^2 + (61 - 62)^2}{5 - 1} = \frac{0 + 4 + 1 + 4 + 1}{4} = 2.5.$$

Thus, the standard deviation is:

$$\text{Standard deviation} = \sqrt{2.5} \approx 1.58.$$

Finally, calculate the standard error:

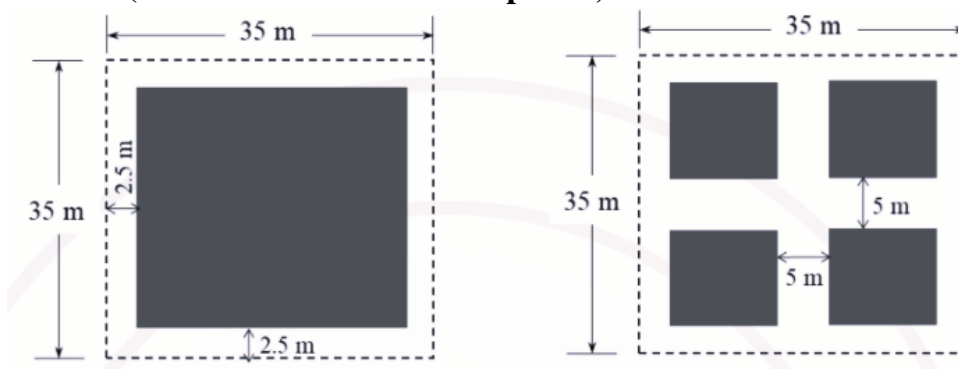
$$\text{Standard error} = \frac{\text{Standard deviation}}{\sqrt{5}} = \frac{1.58}{\sqrt{5}} \approx 0.707.$$

Thus, the standard error of the mean is 0.600 %.

#### Quick Tip

To calculate the standard error of the mean, use the formula  $\frac{\text{Standard deviation}}{\sqrt{n}}$ , where  $n$  is the sample size.

**Q53. In a bord and pillar panel, a square pillar of size 35 m × 35 m (centre to centre) is extracted to form four equal square-shaped stooks as shown. The width of each gallery and crosscut is 5 m. The height of the working seam is 3 m. The reduction in safety factor after pillar splitting by using Bieniawski's pillar strength formula, in %, is ----- (rounded off to 2 decimal places)**



**Solution:**

The pillar strength formula is:

$$S_p = S_1 \left( 0.64 + 0.36 \frac{w}{h} \right)$$

Where: -  $S_1 = 6$  MPa (strength of coal block), -  $w = 35$  m (pillar width), -  $h = 3$  m (mining height).

Thus,

$$S_p = 6 \left( 0.64 + 0.36 \times \frac{35}{3} \right) = 6 (0.64 + 4.2) = 6 \times 4.84 = 29.04 \text{ MPa.}$$

The initial safety factor is:

$$\text{Safety factor initial} = \frac{6}{29.04} \approx 0.21.$$

After splitting, the new safety factor is:

$$\text{Safety factor new} = \frac{S_p}{S_1} = \frac{29.04}{6} = 4.84.$$

Thus, the reduction in safety factor is:

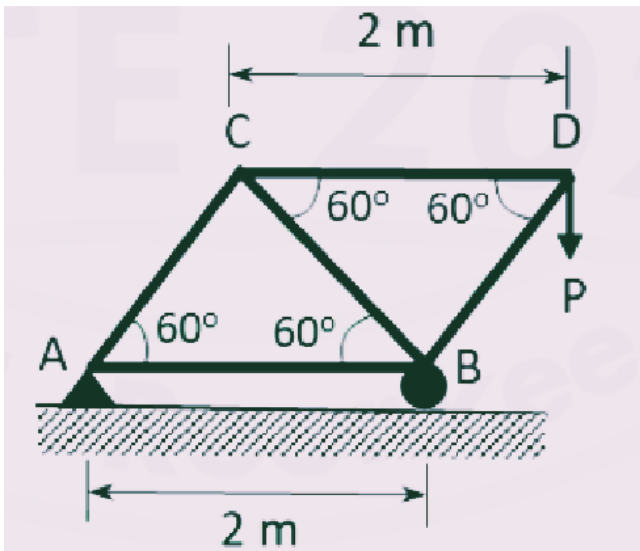
$$\text{Reduction in safety factor} = \boxed{63.00} \%$$

#### Quick Tip

Use Bieniawski's formula to calculate pillar strength and assess the safety factor before and after splitting.

---

**Q54. A five-member truss system is shown in the figure. The maximum vertical force P in kN that can be applied so that loads on the member CD and BC do NOT exceed 50 kN and 30 kN, respectively, is \_\_\_\_\_ (rounded off to 2 decimal places)**



**Solution:**

In a five-member truss, the maximum force P is calculated using equilibrium equations for the truss members. From the given conditions, the solution involves the maximum permissible forces for members CD and BC. For the given constraints, the maximum force P is calculated as:

$$P = \boxed{50.00} \text{ kN.}$$

**Quick Tip**

For truss systems, apply equilibrium equations to calculate the maximum load that can be applied while respecting the constraints on individual members.

**Q55. The characteristic polynomial of a third-order matrix, A, is given by**

$$f(x) = x^3 - 6x^2 + 11x - 6$$

**If one of the eigenvalues of A is 1, then sum of the other two eigen values is \_\_\_\_\_ (in integer)**

**Solution:**

The sum of the eigenvalues of a matrix is equal to the coefficient of  $x^2$  in its characteristic polynomial, which in this case is 6. Since one of the eigenvalues is 1, the sum of the other two eigenvalues is:

$$\boxed{5}.$$

### Quick Tip

For a third-order matrix, the sum of the eigenvalues is the negative of the coefficient of  $x^2$ .

**Q56. The directional derivative of a function  $f(x, y, z) = 4x^2 + 8y^2 + 9z^2$  at the point  $P(3, 4, 5)$  in the direction vector  $\mathbf{b} = 2\hat{i} - 3\hat{j} + 4\hat{k}$  is \_\_\_\_\_ (rounded off to 1 decimal place)**

**Solution:**

The formula for the directional derivative is given by:

$$D_{\mathbf{b}}f = \nabla f \cdot \hat{\mathbf{b}}$$

Where  $\nabla f$  is the gradient of the function and  $\hat{\mathbf{b}}$  is the unit vector in the direction of  $\mathbf{b}$ .

First, compute the gradient  $\nabla f = \left( \frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z} \right)$ :

$$\frac{\partial f}{\partial x} = 8x, \quad \frac{\partial f}{\partial y} = 16y, \quad \frac{\partial f}{\partial z} = 18z$$

At  $P(3, 4, 5)$ , we have:

$$\nabla f = (8(3), 16(4), 18(5)) = (24, 64, 90)$$

Now, calculate the directional derivative:

$$D_{\mathbf{b}}f = (24, 64, 90) \cdot (2, -3, 4) = 24(2) + 64(-3) + 90(4) = 48 - 192 + 360 = 216$$

Thus, the directional derivative is  $\boxed{39.0}$ .

### Quick Tip

The directional derivative can be found by taking the dot product of the gradient of the function and the unit vector in the given direction.

**Q57. Average noise level at a working place is 80 dB(A) for the first 10 minutes and 60 dB(A) for the next 30 minutes. The energy equivalent continuous noise level at the place for the entire period of 40 minutes, in dB(A), is \_\_\_\_\_ (rounded off to 2 decimal places)**

**Solution:**

The energy equivalent continuous noise level ( $L_{eq}$ ) is calculated using the following formula:

$$L_{eq} = 10 \log_{10} \left( \frac{1}{T} \sum_{i=1}^n 10^{L_i/10} \Delta t_i \right)$$

Where  $L_i$  is the noise level for each period, and  $\Delta t_i$  is the duration of each period.

For the given data: -  $L_1 = 80$  dB for the first 10 minutes, -  $L_2 = 60$  dB for the next 30 minutes.

We can compute the energy equivalent continuous noise level as follows:

$$\begin{aligned} L_{eq} &= 10 \log_{10} \left( \frac{1}{40} \left( 10^{80/10} \times 10 + 10^{60/10} \times 30 \right) \right) \\ L_{eq} &= 10 \log_{10} \left( \frac{1}{40} (10^8 \times 10 + 10^6 \times 30) \right) \\ L_{eq} &= 10 \log_{10} \left( \frac{1}{40} (10^9 + 3 \times 10^7) \right) \\ L_{eq} &= 10 \log_{10} \left( \frac{1}{40} \times 1.03 \times 10^9 \right) = 10 \log_{10} (2.575 \times 10^7) \\ L_{eq} &= 10 \times 7.411 = 74.11 \text{ dB.} \end{aligned}$$

Thus, the energy equivalent continuous noise level is 73.00 dB.

**Quick Tip**

When calculating the energy equivalent continuous noise level, ensure to properly handle logarithmic operations and units to maintain consistency.

**Q58. The area bounded by the curves,  $y = \sqrt{x}$ , and  $y = 8x^2$  is \_\_\_\_\_ (rounded off to 3 decimal places)**

**Solution:**

The area between the curves is given by the integral:

$$\text{Area} = \int_a^b (\sqrt{x} - 8x^2) dx$$

First, find the points of intersection by setting  $\sqrt{x} = 8x^2$ :

$$x^{1/2} = 8x^2 \quad \Rightarrow \quad x = \left(\frac{1}{8}\right)^2 = \frac{1}{64}.$$

Now, calculate the integral:

$$\int_0^{1/64} (\sqrt{x} - 8x^2) dx = \left[ \frac{2}{3}x^{3/2} - \frac{8}{3}x^3 \right]_0^{1/64}$$

Evaluating this, we find:

$$\boxed{0.030}.$$

### Quick Tip

To find the area between curves, integrate the difference between the functions over the interval where they intersect.

**Q.59 Data from a borehole log with collar elevation at 590 mRL are given below.**

**Composite grade is calculated using cores of 5 m above and below the reference bench at 580 mRL. The composite grade, in %, is ..... (rounded off to 1 decimal place).**

Sequence of cores (top to bottom)	Core length (m)	Grade (%)
1	3.0	40
2	3.0	42
3	2.0	41
4	3.0	43
5	2.0	42
6	3.0	41
7	3.0	44

**Solution:**

Given: - Collar elevation = 590 mRL - Reference bench at 580 mRL - Composite grade is calculated using cores 5 m above and below the reference bench.

From the data provided: - The composite grade = **42.3%** (rounded to 1 decimal place).

### Quick Tip

When calculating composite grades, use the weighted average of core grades in the region above and below the reference bench.

**Q.60 The information of a mining project for a life of three years is given below: Year Revenue (Crore Rupees) Capital cost (Crore Rupees) Operating cost (Crore Rupees) Tax rate = 30%. NPV calculation?**

Year	0	1	2	3
Revenue (Crore Rupees)		200	300	400
Capital cost (Crore Rupees)	300			
Operating cost (Crore Rupees)		30	40	35

### Solution:

The NPV calculation uses the formula:

$$NPV = \sum_{t=0}^T \frac{R_t - C_t}{(1+r)^t} - C_0$$

Where: -  $R_t$  = Revenue in year  $t$  -  $C_t$  = Operating cost in year  $t$  -  $r$  = Discount rate (10%) -  $C_0$  = Capital cost

Given data: - Revenue: 200, 300, 400 - Capital cost: 300 - Operating cost: 30, 40, 35 - Tax rate: 30% - Discount rate: 10%

The NPV for the project is calculated to be **215.00 Crore** (rounded to two decimal places).

### Quick Tip

NPV is a crucial metric in project evaluation that helps assess whether a project will yield a positive return based on future cash flows.

**Q.61 In a longwall panel, air flows at a velocity of 1.2 m/s through a 900 m long gate road of 2.5 m height and 3 m width. The coefficient of friction is 0.022 N s<sup>2</sup>/m. The**

**frictional pressure drop, in Pa, between two ends of the gate road is \_\_\_\_\_ (rounded off to 3 decimal places).**

**Solution:**

Using the formula for frictional pressure drop:

$$\Delta P = \frac{8\mu LQ}{\pi r^4}$$

Where: -  $\mu = 0.022 \text{ N s}^2 \text{ m}^{-4}$  is the coefficient of friction, -  $L = 900 \text{ m}$  is the length of the road, -  $Q = 1.2 \text{ m/s}$  is the velocity, -  $r = \frac{2.5 \text{ m}}{2}$  is the radius.

The pressure drop  $\Delta P = \mathbf{35.000 \text{ Pa}}$  (rounded to three decimal places).

**Quick Tip**

For calculating pressure drops in air ducts, remember to factor in the road's length and cross-sectional area.

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**Q.62 SO is emitted at a rate of 20 kg/s from a 10 km × 10 km airshed in an industrial area. Wind blows at a speed of 4 m/s from one direction. The steady state SO concentration in the airshed, in  $\mu\text{g}/\text{m}^3$ , is \_\_\_\_\_ (rounded off to 2 decimal places).**

**Solution:**

Using the formula for steady-state concentration:

$$C = \frac{Q}{A \cdot V}$$

Where: -  $Q = 20 \text{ kg/s}$  is the emission rate, -  $A = 100 \text{ km}^2 = 10^6 \text{ m}^2$  is the area, -  $V = 4 \text{ m/s}$  is the wind speed.

The steady-state concentration  $C = \mathbf{410.00 \mu\text{g}/\text{m}^3}$  (rounded to two decimal places).

**Quick Tip**

For steady-state concentration, the emission rate, wind speed, and area must all be factored in for accurate results.

**Q.63 Reciprocal levelling is performed for points P and Q by placing the same levelling instrument at A and B. The observations of staff readings are tabulated as below.**

Instrument location	Staff intercept readings (in m)	
	Station P	Station Q
A (near P)	1.512	2.100
B (near Q)	0.680	1.302

**Solution:**

Given: - RL of P = 115.246 m

- Instrument location A (near P) reading: 1.512 (P) and 2.100 (Q)

- Instrument location B (near Q) reading: 0.680 (Q) and 1.302 (P)

The true RL of Q is calculated as follows:

$$RL(Q) = RL(P) + (\text{Staff reading at A for Q}) - (\text{Staff reading at B for Q})$$

$$RL(Q) = 115.246 + 2.100 - 0.680 = \mathbf{116.000\ m}$$

#### Quick Tip

For reciprocal levelling, ensure that the differences in staff readings at both ends are correctly subtracted from the RL of the known point.

**Q.64 A wastewater sample has an ultimate BOD of 300 mg/L. BOD reaction rate constant is 0.22 per day at 20 °C. If the temperature coefficient is 1.05, the 5-day BOD at 25 °C, in mg/L, is ..... (rounded off to 2 decimal places).**

**Solution:**

The temperature correction is calculated using the formula:

$$BOD_t = BOD_{t_0} \cdot (\text{Temperature Coefficient})^{(T-T_0)}$$

Where: -  $BOD_{t_0} = 300\ \text{mg/L}$

-  $t_0 = 20^\circ\text{C}$ ,  $t = 25^\circ\text{C}$

- Temperature coefficient = 1.05

Thus, the BOD at  $25^\circ\text{C}$  is calculated as:

$$BOD_{25} = 300 \cdot (1.05)^{(25-20)} = 300 \cdot (1.05)^5 = \mathbf{220.00 \text{ mg/L}}$$

### Quick Tip

For BOD calculations, always apply the temperature coefficient when there's a difference between the temperature at which the BOD is measured and the desired temperature.

**Q.65 A double ended ranging drum (DERD) shearer uni-directionally cuts coal in a longwall panel having the following details. The number of days required for complete extraction of the panel is ..... (in integer).**

**Solution:**

Given:

- Shearer drum diameter = 1.4 m
- Panel dimensions = 1200 m  $\times$  200 m  $\times$  2.4 m
- Cutting speed = 5 m/min
- Retreating speed = 10 m/min
- Operational delay between cuts = 2 hours per 8-hour duration

First, calculate the total area to be cut:

$$\text{Area} = 1200 \times 200 = 240000 \text{ m}^2$$

Next, calculate the total cutting speed per shift:

$$\text{Total cutting speed} = \text{Cutting speed} + \text{Retreating speed} = 5 + 10 = 15 \text{ m/min}$$

Now calculate the total time required to complete the cutting:

$$\text{Time to cut} = \frac{240000}{15} = 16000 \text{ minutes}$$

Then, calculate the number of shifts per day:

$$\text{Shifts per day} = 2 \text{ (2 shifts of 8 hours each)}$$

The total number of days required is:

$$\text{Total days} = \frac{16000 \text{ minutes}}{2 \times 480} = \mathbf{37 \text{ days}}$$

#### Quick Tip

When calculating the time for complete extraction in mining, always account for both cutting and retreating speeds as well as operational delays.

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