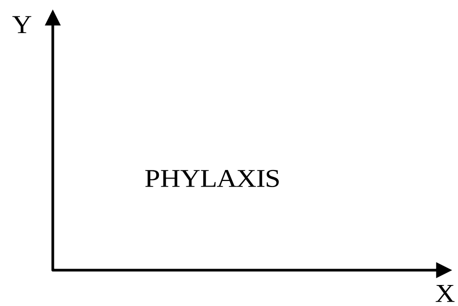
GENERAL APTITUDE

Q. No: 1-5 Carry One Mark Each

1. The mirror image of the above text about the x-axis is



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

[1-Mark, MCQ]

Key: (A)

Sol:

($\because$ Mirror image of any text about a line is symmetrical about the line).

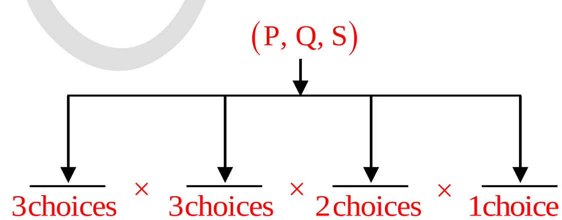
Hence option (A).

2. Four persons P, Q, R and S are to be seated in a row, R should not be seated at the second position from the left end of the row. The number of distinct seating arrangement possible is: **[1-Mark, MCQ]**

(A) 6 (B) 18 (C) 9 (D) 24

Key: (B)

Sol:



The number of distinct seat arrangements $= 3 \times 3 \times 2 \times 1 = 18$

3. $\oplus$ and $\odot$ are two operators on numbers p and q such that

$p \odot q = p - q$, and $p \oplus q = p \times q$

Then, $(9 \odot (6 \oplus 7)) \odot (7 \oplus (6 \odot 5)) =$ **[1-Mark, MCQ]**

(A) –33 (B) –40 (C) 40 (D) –26

Key: (B)

Sol: $(9 \odot (6 \oplus 7)) \odot (7 \oplus (6 \odot 5))$

$= (9 - (6 \times 9)) - (7 \times (6 - 5)) = (9 - 42) - (7 \times 1) = -33 - 7 = -40$

4. **(i)** Arun and Aparna are here.

(ii) Arun and Aparna is here.

(iii) Arun's families is here.

(iv) Arun's family is here.

Which of the above sentences are grammatically CORRECT? **[1-Mark, MCQ]**

(A) (ii) and (iv) (B) (i) and (ii) (C) (i) and (iv) (D) (iii) and (iv)

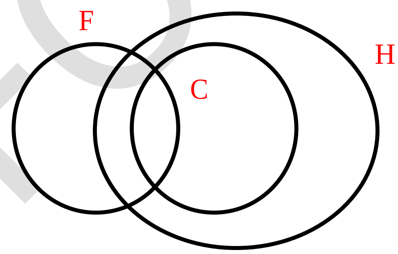
Key: (C)

Sol: F → Football players

C → Cricket players

H → Hockey players

∴ Some football players play hockey



5. Two identical cube shaped dice each with faces numbered 1 to 6 rolled simultaneously. The probability that an even number is rolled out on each dice is: **[1-Mark, MCQ]**

(A) $\frac{1}{12}$ (B) $\frac{1}{8}$ (C) $\frac{1}{36}$ (D) $\frac{1}{4}$

Key: (D)

Sol: Total number of events in sample space $= 6 \times 6 = 6^2 = 36.$

No. of favourable events of event A = $3 \times 3 = 9$

∴ Required probability $= \frac{9}{36} = \frac{1}{4}$

Q. No: 6-10 Carry Two Marks Each

6. In an equivalent triangle PQR, side PQ is divided into four equal parts, side QR is divided into six equal parts and side PR is divided into eight equal parts. The length of each subdivided part in cm is an integer.

The minimum area of the triangle PQR possible, in cm^2, is

(A) $144\sqrt{3}$ (B) $48\sqrt{3}$ (C) 18 (D) 24

[2-Marks, MCQ]

Key: **(A)**

Sol: Let us assume, the length of side of an equilateral triangle = 24cm. (L.C.M of 4, 6, 8 = 24)

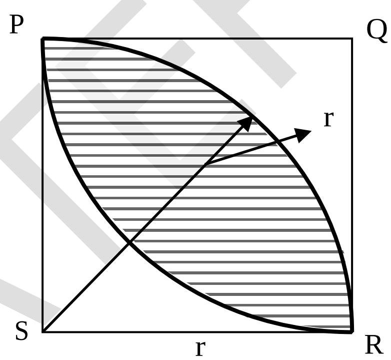
To have minimum area of triangle PQR & length of each sub divided part is an integer).

$\therefore$ Area of an equilateral triangle $=\frac{\sqrt{3}}{4}a^2$, where a is the length of the side

$$=\frac{\sqrt{3}}{4}\times(24)^2=\frac{\sqrt{3}}{4}\times 24\times 24=144\sqrt{3}\,cm^2$$

7. In the figure shown above, PQRS is a square. The shaded portion is formed by the intersection of sectors of circles with radius equal to the side of the square and centers at S and Q.

[2-Marks, MCQ]

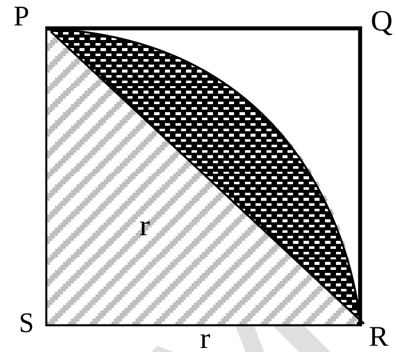


The probability that any point picked randomly within the square falls in the shaded area is ______.

(A) $\frac{\pi}{4}$ (B) $4-\frac{\pi}{2}$ (C) $\frac{1}{2}$ (D) $\frac{\pi}{2}-1$

Key: **(D)**

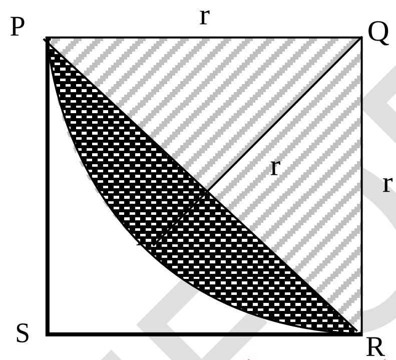
Sol: $\text{Total area} = r \times r = r^2$



$$\text{Favourable area} = \underbrace{\left(\frac{1}{4}\pi r^2\right.}_{\text{Area of quarter circle}} - \underbrace{\left.\frac{1}{2}r^2\right)}_{\text{Area of } \Delta PSR} + \left(\frac{1}{4}\pi r^2 - \frac{1}{2}r^2\right)$$

$$= 1\left(\frac{1}{4}\pi r^2 - \frac{1}{2}r^2\right)$$

$$\therefore \text{Required probability} = \frac{2\left(\frac{1}{4}\pi r^2 - \frac{1}{2}r^2\right)}{r^2} = \frac{\pi}{2} - 1$$



$$\text{Shaded portion} = \left(\frac{1}{4}\pi r^2 - \frac{1}{2}r^2\right)$$

8. **1.** Some football players play cricket.

2. All cricket players play hockey.

Among the options given below, the statement that logically follows from the two statements 1 and 2 above, is

(A) All hockey players play football

(B) No football player plays hockey

(C) All football players play hockey

(D) Some football players play hockey

[2-Marks, MCQ]

Key: **(D)**

9. On a planar field, you travelled 3 units East from a point O. Next you travelled 4 units South to arrive at point P. Then you travelled from P in the North-East direction such that you arrive at a point that is 6 units East of point O. Next, you travelled in the North-West direction, so that you arrive at point Q that is 8 units North of point P. The distance of point Q to point O, in the same units, should be ______

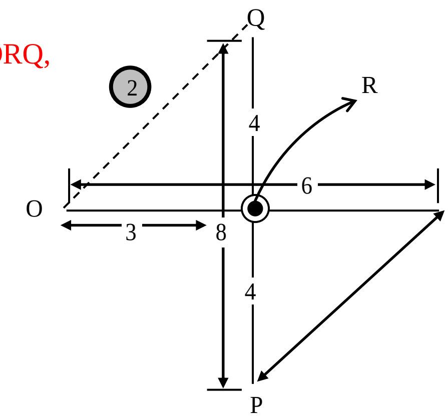
(A) 3 (B) 6 (C) 4 (D) 5

[2-Marks, MCQ]

Key: **(D)**

Sol: From right angle triangle ORQ,

$$OQ^2 = OR^2 + RQ^2$$
$$= 3^2 + 4^2$$
$$= 9 + 16 = 25$$
$$\Rightarrow OQ = \sqrt{25} = 5$$



10. The author said, "Musicians rehearse before their concerts. Actors rehearse their roles before the opening of a new play. On the other hand, I find it strange that many public speakers think they can just walk on to the stage and start speaking. In my opinion, it is no less important for public speakers to rehearse their talks". Based on the above passage, which one of the following is TRUE?

(A) The author is of the opinion that rehearsing is important for musicians, actors and public speakers

(B) The author is of the opinion that rehearsing is more important only for musicians than public speakers

(C) The author is of the opinion that rehearsal is more important for actors than musicians

(D) The author is of the opinion that rehearsing is less important for public speakers than for musicians and actors

[2-Marks, MCQ]

Key: **(A)**

MINING ENGINEERING

Q. No: 1-25 Carry One Mark Each

1. Tricone roller bit is used with

(A) down-the-hole hammer
(B) Jack hammer
(C) rotary-percussive drill
(D) rotary drill

Key: (D)

2. Reusing method of mining is practiced for

(A) thick vein deposit
(B) massive shallow deposit
(C) narrow vein deposit
(D) massive deep-seated deposit

Key: (C)

3. The equipment used for both drop cut and terrace cut in surface mining is

(A) surface miner
(B) shovel
(C) dragline
(D) bucket wheel excavator

Key: (D)

4. Surface miner does NOT have a

(A) differential gear for turning
(B) tensioning arrangement for crawler
(C) scraper plate behind the drum
(D) pick cooling system

Key: (A)

5. Induced blasting enhances production in

(A) sublevel stoping
(B) block caving
(C) cut and fill mining
(D) shrinkage stoping

Key: (B)

6. The measures of dispersion of a dataset are

(A) standard deviation, range and mode
(B) standard deviation, range and interquartile range
(C) variance, range and median
(D) interquartile range, median and mode

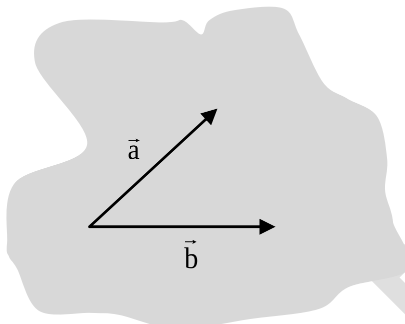
Key: (B)

7. NONEL is used as down-the-hole initiator to

(A) avoid generation of air overpressure
(B) provide precise delay
(C) avoid deflagration of column charge
(D) reduce ground vibration

Key: (C)

8. The vector $\vec{a}$ and $\vec{b}$ act in a plane as shown below. The magnitude of the vector $\vec{c} = \left(\vec{a}+\vec{b}\right)\times\left(\vec{a}-\vec{b}\right)$ is



(A) zero
(B) half to the area bounded by the vectors $\vec{a}$ and $\vec{b}$
(C) equal to the area bounded by the vectors $\vec{a}$ and $\vec{b}$
(D) twice the area bounded by the vectors $\vec{a}$ and $\vec{b}$

Key: (D)

Sol: $\vec{C} = \left(\vec{a}+\vec{b}\right)\times\left(\vec{a}-\vec{b}\right)$

$= \vec{a}\times\vec{a} - \vec{a}\times\vec{b} + \vec{b}\times\vec{a} - \vec{b}\times\vec{b}$

$= \vec{0} - 2\left(\vec{a}\times\vec{b}\right) - \vec{0} \qquad \left(\because \vec{b}\times\vec{a} = -\left(\vec{a}\times\vec{b}\right)\right)$

$= -2\left(\vec{a}\times\vec{b}\right)$

$\Rightarrow \left|\vec{C}\right| = 2\left|\vec{a}\times\vec{b}\right|$, which is twice the are bounded by the vectors $\vec{a}$ and $\vec{b}$

$\therefore$ Option (D)

9. As per MMDR Act 1957, for the allocation of lease of minor minerals

(A) the State Government is authorized to give the permit
(B) the Central Government is authorized to give the permit
(C) the State Government is authorized to give permit but with the consent of Central Government
(D) the Central Government is authorized to give permit but with the consent of State Government

Key: (A)

10. In photogrammetry, the 'Tilt of a photograph' refers to the angle between the

(A) lines joining the opposite fiducial marks of a photograph

(B) normal to the plane of photograph and optical axis

(C) vertical and the axis of the flight

(D) vertical and optical axis of the camera

Key: (D)

11. The hydraulic sand stowing pipeline layout should be such that

(A) the geometric profile must coincide with the hydraulic gradient line

(B) the hydraulic profile should always be below the hydraulic gradient line

(C) the hydraulic profile should always be above the hydraulic gradient line

(D) the geometric profile should always be above the hydraulic gradient line

Key: (B)

12. For a "positive definite" square matrix, the TRUE statement is

(A) the matrix is singular

(B) all the eigen values of the matrix are greater than zero

(C) all the given values of the matrix are zero

(D) some of the eigen values can be less than zero

Key: (B)

Sol: We know that all the eigen values of a "positive definite" square matrix are positive (i.e., greater than zero).

13. The standard normal distribution is a

(A) non-parametric distribution

(B) single parameter distribution

(C) two-parameter distribution

(D) three-parameter distribution

Key: (C)

Sol: $\underbrace{\text{Normal distribution}}$ has two parameter μ and σ

$$N\left(\mu, \sigma^2\right)$$

but standard normal distribution is N(0, 1) (i.e., mean = 0, SD = 1)

$\therefore$ It is non-parametric distribution option (C)

14. Variance of the sum of two statistically independent random variables X and Y, σ^2_{X+Y}, is

(A) $\sigma^2_X + \sigma^2_Y$ (B) $\sigma^2_X + \sigma^2_Y + 2\sigma_{XY}$

(C) $\sigma^2_X + \sigma^2_Y + \sigma_{XY}$ (D) $\sigma^2_X + \sigma^2_Y - 2\sigma_{XY}$

Key: (A)

Sol: $\sigma^2_{X+Y} = \text{Var}(X+Y) = \text{Var}(X) + \text{Var}(Y)$, Since X, Y are independent random variables

$= \sigma^2_X + \sigma^2_Y$, option (A).

$\left(\because \text{Var}(ax+by) = a^2\text{Var}(x) + b^2\text{Var}(y), \text{ if } x, y \text{ are independent random variables}\right)$

15. The difference between depreciation and amortization allowances in tax calculation is that

(A) depreciation is for a tangible asset applicable on its declared life; whereas amortization is for an intangible asset applicable on a specified period

(B) depreciation is for an intangible asset applicable on its declared life; whereas amortization is for a tangible asset applicable on a specified period

(C) depreciation is for a tangible asset applicable on a specified period; whereas amortization is for an intangible asset applicable on its declared life

(D) depreciation is for an intangible asset applicable on a specified period; whereas amortization is for a tangible asset applicable on its declared life

Key: (A)

16. Owning cost of a machine does NOT include

(A) purchase price (B) insurance (D) interest (D) operating cost

Key: (D)

17. Folds are the structural features resulting from

(A) ductile deformation of earth crust

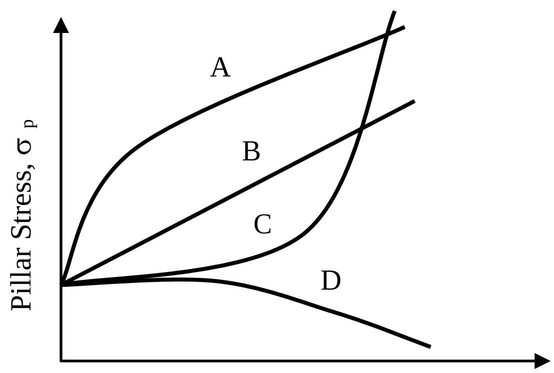
(B) brittle deformation of earth crust

(C) high impact tectonic stresses of earth crust

(D) fracturing of earth crust

Key: (A)

18. The CORRECT curve showing relationship between vertical stress on a coal pillar and extraction ratio of a bord and pillar panel in a horizontal seam is



(A) Curve A (B) Curve B (C) Curve C (D) Curve D

Key: (C)

19. Given impeller diameter D, speed of a rotation n and air density ρ, for geometrically similar fans, the fan pressure is proportional to

(A) $nD^2\rho$ (B) $n^2D^2\rho$ (C) $n^2D^5\rho^2$ (D) $n^3D^5\rho$

Key: (B)

Sol: Change in pressure is directly proportional to the square as impeller dia D ratio or the square of speed at ratio or the square of speed at ratio.

$$\frac{H_2}{H_1} = \frac{D_2^2}{D_1^2}$$

$$\frac{H_2}{H_1} = \frac{N_2^2}{N_1^2}$$

20. A coal sample having moisture content of 8.0% has unit weight 15.6 kN/m^3. The dry unit weight of the sample, in kN/m^3 is ___________.

Key: (14.44)

Sol: Given that

$m = 80\%$

$\gamma = 15.6\ kN/m^3$

Dry unit weight??

$\gamma_d = \dfrac{\text{Bulk unit weight}}{1+m} = \dfrac{15.6}{1+0.08} = 14.44$

21. The value of the integral $I = \int_0^4 \sqrt{x}dx$ computed using Simpson's 1/3 rule with 2 subintervals is ________. (round off to 3 decimal places)

Key: **(5.1)**

Sol: $f(x) = \sqrt{x}, a = 0, b = 4, n = 2 \Rightarrow h = \dfrac{b-a}{n} = 2$

$y_0 = f(\underset{a}{\underset{\downarrow}{0}}) = \sqrt{0} = 0; \; y_1 = f(a+h) = \sqrt{2} \approx 1.414$

$y_2 = f(a+2h) = \sqrt{4} = 2$

$\therefore$ By Simpson's $\dfrac{1}{3}$rd rule,

$\int_0^4 \sqrt{x}dx = \dfrac{h}{3}\left[(y_0 + y_2) + 4y_1\right] = \dfrac{2}{3}[2 + 5.656] \approx 5.104$

22. In the context of sound frequency analysis, the lower and upper frequencies of a 1/1 octave band are 710 Hz and 1420 Hz respectively. The corresponding centre frequency of the band in Hz, is _______. (round off to the nearest integer).

Key: **(1004)**

Sol: Central frequency band $= \sqrt{f_1 f_2} = \sqrt{710 \times 1420} = 1004.09$

23. In Battle Environmental Evaluation System (BEES) of Environmental Impact Assessment (EIA), "air pollution" has a Parameter Important Unit (PIU) value of 52. The Environmental Quality (EQ) score of a project with respect to air pollution was 0.8 before the project implementation and it becomes 0.6 after the project implementation. The difference in the "Environmental Impact Unit (EIU)", before and after the project implementation is _________. (round off to 2 decimal places)

Key: **(10.4)**

Sol: Given that, $PIU = 52$

$EQ_1 = 0.8$

$EQ_2 = 0.6$

Now environmental input unit = Difference of EIU

$= 52 \times 0.8 - 52 \times 0.6$

$= 10.4 [\text{Where EIU} = \text{PIU} - \text{EQ}]$

24. A system consists of four components connected functionally in a parallel configuration. The reliability of the individual components is 0.40, 0.60, 0.50 and 0.40. The system reliability, is ________ (round off to 3 decimal places)

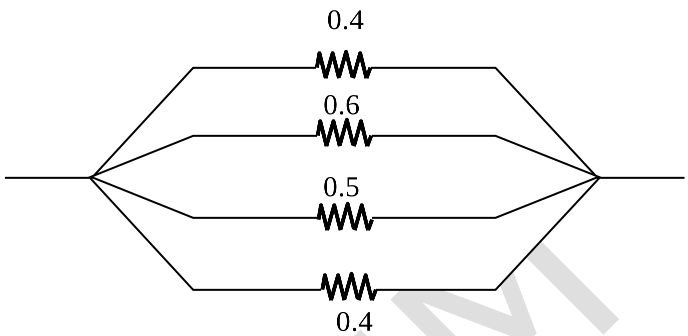
Key: **(0.92)**

Sol: System reliability

$=1-(1-R_1)(1-R_2)(1-R_3)(1-R_4)$

$=1-\left[(1-0.4)(1-0.6)(1-0.5)(1-0.4)\right]$

$=0.92$



25. A vehicle is moving at a speed of 12 m/s on a level road. It applies emergency brakes and starts to skid without rolling in a straight path. The deceleration of the vehicle is constant after braking and it comes to rest at a distance of 15m. Assuming, $g = 10\,m/s^2$, the coefficient of kinetic friction between the tyres and road is __________ (round off to 2 decimal places)

Key: **(0.48)**

Sol: Given that,

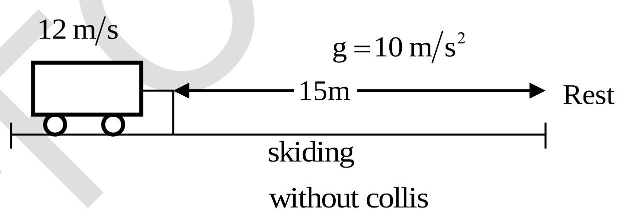
$v = 12\,m/s$

$g = 10\,m/s^2$

Initial velocity = 12 m/s = U

Final velocity = 0 = u

From equation motion



$\vartheta^2 = u^2 - 2as$

$\theta^2 = 12^2 - 2 \times a \times 15$

$a = \frac{144}{30} = 4.8\,m/s^2$

(a will be retardation)

Frictional frame on vehicle $= \mu mg = ma$

$\mu g = a$

$\mu \times 10 = 4.8$

$\mu = \frac{4.8}{10} = 0.48$

Method-II

$$\frac{1}{2}mv^2 = \mu mg\cos\theta \times \text{distance}$$

$$\frac{1}{2}\times 12^2 = \mu \times 10 \times \cos 0° \times 15$$

$$\mu = 0.48$$

Q. No: 26-55 Carry Two Marks Each

26. In a bord and pillar panel six shuttle cars, each of 10 tonne capacity, are deployed to transport coal produced by two continuous miners to a belt conveyor. Each shuttle car on an average carries 80% of its rated capacity and makes 7 round trips in an hour. The belt conveyor has a capacity such that the effective material cross section area is of 0.09 m^2 and runs at a speed 1.1 m/s. The broken coal has a bulk density of 1.2 tonne/m^3. The ratio between the production and the capacity of the belt conveyor, in percent is

(A) 65.46 (B) 71.42 (C) 78.56 (D) 82.46

Key: (C)

Sol: Number of shuttle car = 6

Capacity = 10 tonne

Number of condition mixer = 2

Belt $A = 0.09\ A^2$

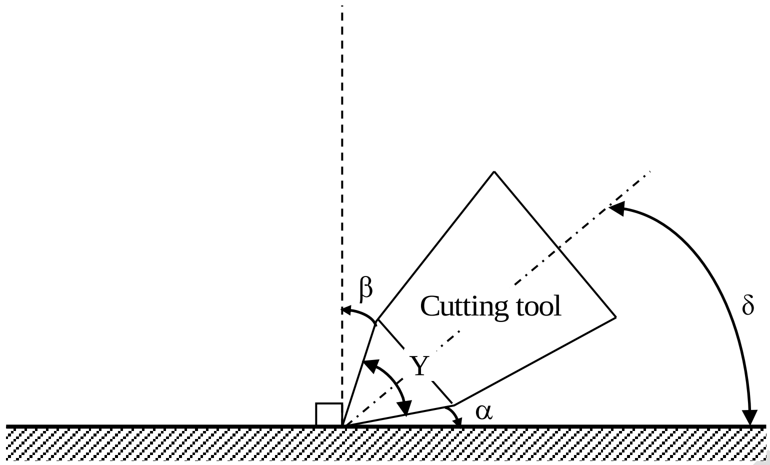
$v = 1.1\ m/s$

$b = 1.2\ \text{tonne}/m^3$

$$\frac{\text{Production}}{\text{Capacity of belt conveyor}} = \frac{6\times 10\times 0.8\times 7}{(0.09\times 1.1\times 1.2\times 3600)}\times 100 = 78.56\%$$

27. With reference to the figure related to rock cutting by point attack tool, match the angle with corresponding name

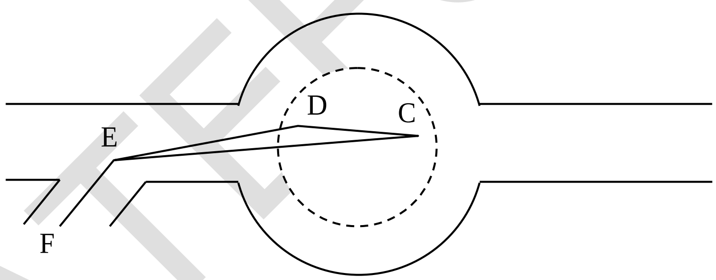
Angle	Name
P. α	**1.** Cutting angle
Q. β	**2.** Clearance angle
R. δ	**3.** Wedge angle
S. γ	**4.** Rake angle



(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-4, R-3, S-1
(D) P-4, Q-2, R-3, S-1

Key: **(A)**

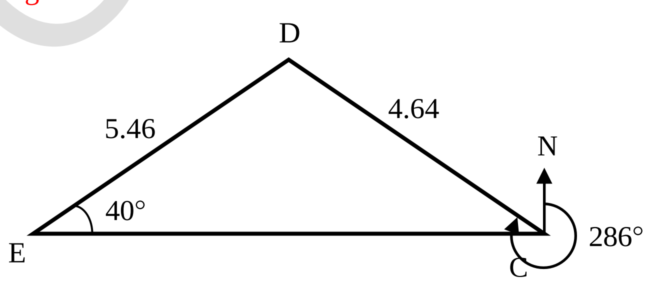
28. The pit bottom in a correlation survey is shown in the figure. Points C and D represents two suspended wires. The bearing of line CD is $286°00'00''$ and its length is 4.64m. The angle CED is measured as $00°00'40''$. The length of line DE is 5.46m. Considering the Weisbach triangle method, the bearing of the line CE is



(A) $286°00'47''$
(B) 285°59'12.9"
(C) 286°00'40"
(D) 285°00'47.1"

Key: **(B)**

Sol: From figure



From sine rule

$$\frac{CD}{\sin E} = \frac{ED}{\sin C}$$

$$\frac{4.64}{\sin 40"} = \frac{5.46}{\sin C}$$

$$C = 47.07"$$

Now Bearing of CE = Bearing of CD - < C

$$= 286° - 47.07"$$

$$= 285°59'12.93"$$

29. A dump truck moves up an incline of 5^0 with constant tractive force of 800 kN. The gross mass of the truck is 250 tonne and its rolling resistance is 545 kN. The acceleration due to gravity is 10 m^2/s. The time required, in s, to reach a speed of 3.3 m/s from 1.0 m/s is

(A) 22.0 (B) 15.5 (C) 3.3 (D) 0.2

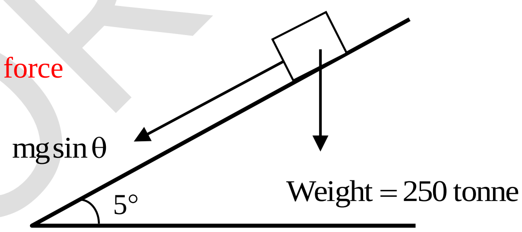
Key: (B)

Sol: Drawbar pull = Tractive fore – Rolling resistor – sliding force

$$= 800 - 545 - mg\sin\theta$$

= 800 – 545 – 250 × 10 × sin 5

= 37.11 kN



$$\text{Now } F = ma = m\frac{v}{t} = 37.11 = 250 \times \frac{2.3}{t} \Rightarrow t = 15.5\,\text{sec}$$

30. In a longwall panel, face is supported with shield of yield capacity 460 tonne per shield. The distance from the canopy tip to coal face is 0.15 m when the support is fully advanced. The depth of web is 0.60m. The shields are set skin to skin at the face. Length of the canopy of the shield is 3.25 m and width 1.5 m. Setting capacity is 80% of the yield capacity. The setting resistance at the maximum and minimum span of the coal face, in $tonne/m^2$, respectively are

(A) 61.33 and 72.15 (B) 63.72 and 75.48

(C) 76.666 and 90.19 (D) 91.99 and 108.22

Key: (A)

Sol: Given that,

Yield capacity of shield = 460 tonnes/shield

Distance (coal to canopy tip) = 0.15 mm

Web = 0.6m

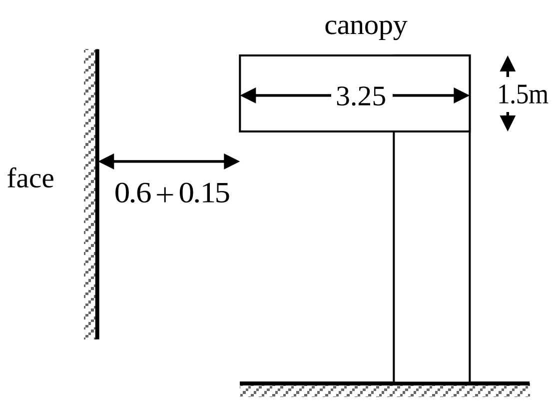
Length canopy = 3.25 m

Width = 1.5m

Capacity = 80%

Setting capacity = 80% of 460 $= 460 \times \frac{80}{100} = 368 \text{ tonne/shield}$

Maximum area supported by canopy $= 4 \times 1.5 = 6\text{m}^2$



Minimum area supported by canopy Support Resistance $= 3.4 \times 1.5 = 5.1\,\text{m}^2$

$$\text{Max} = \frac{368}{6} = 61.33 \text{ tonne/m}^2$$

$$\text{Min} = \frac{368}{5.1} = 72.15 \text{ tonne/m}^2$$

31. A 10 m*l* sample of wastewater is diluted with water having no BOD, to fill a 300 ml BOD bottle. The initial DO of the diluted waste water is 9.0 mg/*l*. If the BODs of the waste water sample is 60 mg/*l*, the final DO of the diluted waste water in mg/*l*, is

(A) 5.0 (B) 6.0 (C) 7.0 (D) 8.0

Key: (C)

Sol: $\text{BOD sample}\,(\text{mg/m}\ell) = \frac{\text{DO depletion}\,(\text{mg/m}\ell)}{\text{Sample volume}\,(\text{m}\ell)} \times \text{Volume diluted}\,(\text{m}\ell)$

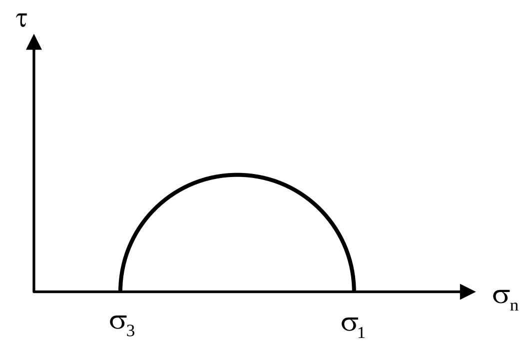
$[\text{DO depletion} = \text{DO}_{\text{initial}} - \text{DO}_{\text{final}}]$

$$\Rightarrow 60\,\text{mg/m}\ell = \frac{(9 - \text{DO}_{\text{final}})\,\text{mg/m}\,\ell}{10\,\text{m}\ell} \times 300\,\text{m}\ell$$

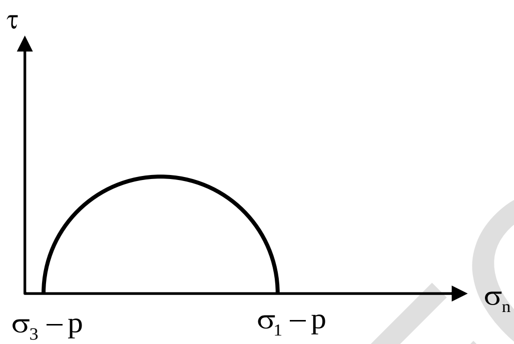
$$\Rightarrow 9 - \text{DO}_{\text{final}} = 2$$

$$\Rightarrow \text{DO}_{\text{final}} = 7\,\text{mg/m}\ell$$

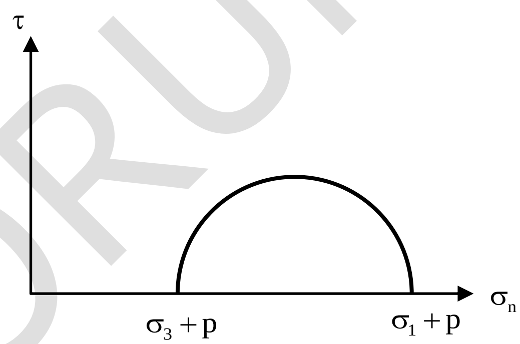
32. The Mohr circle of stress of a dry porous rock is shown in the figure. If the rock is fully saturated with a pore pressure p, then the Mohr circle takes the form of



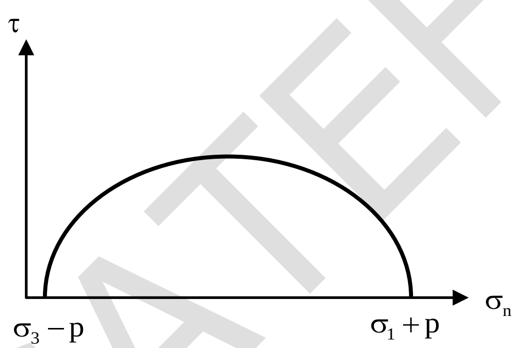
(A)



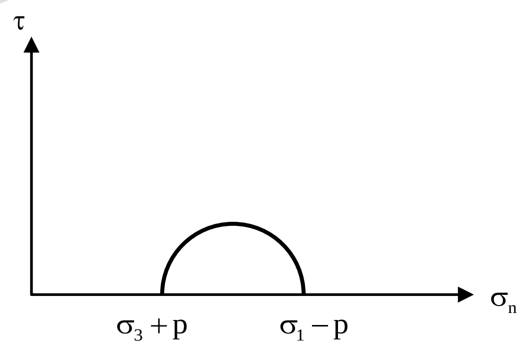
(B)



(C)

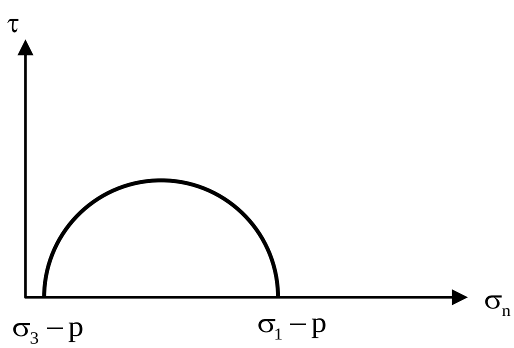


(D)

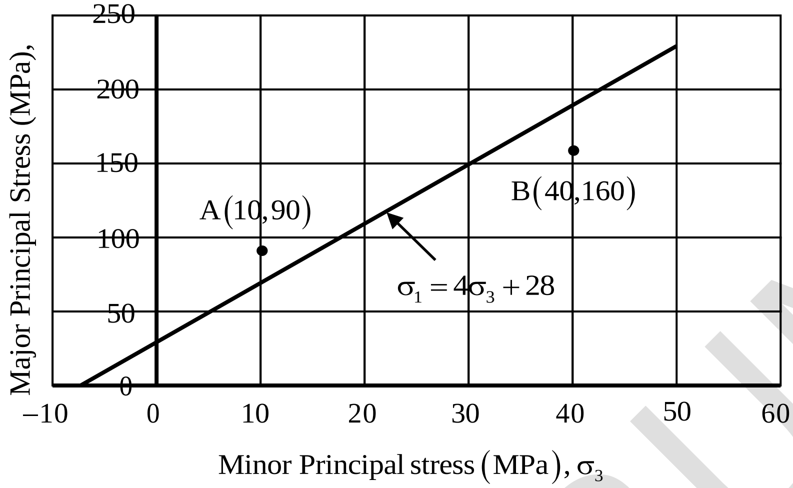


Key: **(A)**

Sol: If the lock is fully saturated with a pore pressure P, then P will be subtracted from the principal stress since, the Mohr diagram shown in under tri-axial condition.



33. The straight line shown depicts the failure criterion of a rock type. The values of stress at points A and B are as shown. The safety factor at the points A and B respectively are



(A) 1.175 and 0.755

(B) 1.324 and 0.851

(C) 0.851 and 1.324

(D) 0.755 and 1.175

Key: **(D)**

Sol: $\sigma_1 = 4\sigma_3 + 28$

for $\sigma_3 = 10$ (at point A)

$\sigma_1 = 4 \times 10 + 28 = 68$

But at $A_1 \sigma_1 = 90$

So, factor of safety at $A = \frac{68}{90} = 0.755$

At point B,

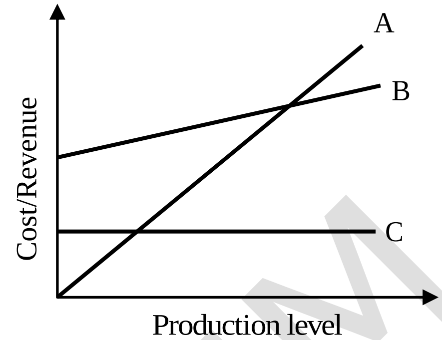
$\sigma_1 = 160 \;\&\; \sigma_3 = 40$

$\sigma_1 = 4 \times 40 + 28 = 188$

So, factor of safety at $B = \frac{188}{160} = 1.175$

34. Figure shown relates to the manufacture of roof bolts. With respect to the cost/revenue vs production level, match the appropriate trend line with corresponding description

Line	Item
P. A	**1.** Total cost
R. B	**2.** Indirect operating cost
S. C	**3.** Revenue



(A) P-1, Q-3, R-2 (B) P-2, Q-1, R-3

(C) P-1, Q-2, R-3 (D) P-3, Q-1, R-2

Key: **(D)**

Sol: Total cost = fixed cost + variable cost

$\boxed{C_T = C_f + PC_V}$

Total revenue = PS_P

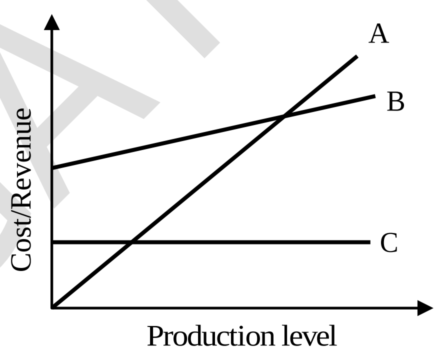
Where, C_f = fixed cost

P = Production in tonnes

S_P = Selling Price

C_V = Variable cost

Note: Indirect costs do not vary substantially within certain production. So are considered to be fixed cost



A : Revenue

B : Total cost

C : Indirect operating cost

35. The value of $\lim_{x\to\infty}\left(x\sqrt{x^2+b^2}-\sqrt{x^4+b^4}\right)$ is

(A) 0 (B) $\frac{b^2}{2}$ (C) ∞ (D) b^2

Key: (B)

Sol: $\lim_{x\to\infty}\left(x\sqrt{x^2+b^2}-\sqrt{x^4+b^4}\right)\to\infty-\infty$ form

$$=\lim_{x\to\infty}\frac{\left(x\sqrt{x^2+b^2}-\sqrt{x^4+b^4}\right)\left(x\sqrt{x^2+b^2}+\sqrt{x^4+b^4}\right)}{\left(x\sqrt{x^2+b^2}+\sqrt{x^4+b^4}\right)}$$

$$=\lim_{x\to\infty}\left(\frac{x^2\left(x^2+b^2\right)-\left(x^4+b^4\right)}{x\sqrt{x^2+b^2}+\sqrt{x^4+b^4}}\right)$$

$$=\lim_{x\to\infty}\left(\frac{b^2x^2-b^4}{x\sqrt{x^2+b^2}+\sqrt{x^4+b^4}}\right)=\lim_{x\to\infty}\frac{x^2\left(b^2-\frac{b^4}{x^2}\right)}{x^2\left[\sqrt{1+\frac{b^2}{x^2}}+\sqrt{1+\frac{b^4}{x^4}}\right]}$$

$$=\frac{b^2-0}{\sqrt{1+0}+\sqrt{1+0}}=\frac{b^2}{2}, \text{ option (B)}$$

36. In order to check whether iron ore is supplied to the specification of 62% Fe, a steel company has conducted a hypothesis test with the null hypothesis as $H_0:\ \mu F_e=62\%$ and alternative hypothesis Ha: $\mu F_e<62\%$. A random sample of 5 observation reveal the following grade values of the lot, 58%, 56%, 60%, 64%, 62%. The t-test statistic for the hypothesis is

(A) –3.000 (B) 1.414 (C) –1.414 (D) 3.000

Key: (C)

Sol: Average grade values, $\bar{x}=\frac{58+56+60+64}{5}=\frac{300}{5}=60$

Null hypothesis, $H_o:\mu=62$

Alternate hypothesis $H_a:\mu<62$

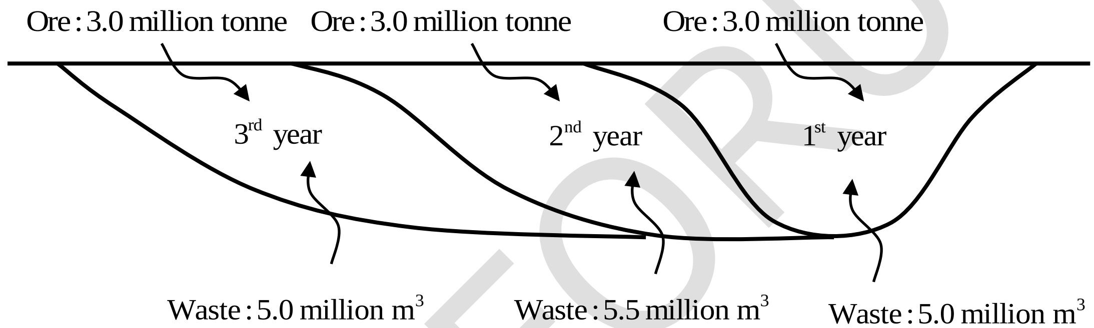
$$\sigma=\sqrt{\frac{\sum_{i=1}^{n}\left(x_i-\bar{x}\right)^2}{n-1}}$$

$$\Sigma(x_i - \bar{x})^2 = (58-60)^2 + (56-60)^2 + (60-60)^2 + (64-60)^2 + (62-60)^2$$
$$= 4 + 16 + 0 + 16 + 4$$
$$= 40$$

$$\sigma = \sqrt{\frac{40}{4}} = \sqrt{10}$$

$$t = \frac{\bar{x} - \mu}{\sigma/\sqrt{n}} = \frac{60-62}{\sqrt{10}/\sqrt{5}} = \frac{-2}{\sqrt{2}} = -\sqrt{2} = -1.414$$

37. Production planning of a small quarry having 3 years of life is shown in the figure. The following information of revenue and cost data are available.



Selling price of ore = Rs. 1500/tonne

Ore mining cost = Rs. 500/tone

Waste mining cost = Rs. 500/m^3

Initial capital = Rs. 1000 million

Discount rate = 10%

By neglecting depreciation, salvage value and corporate tax, the NPV of the mining project, in million Rs., is _______ (round off to 2 decimal places)

Key: **(36.81)**

Sol: Initial capital = Rs 1000 million

For 1st year

Ore = 3 million tonne

Waste = 5 million m^3

$$\text{Selling price} = \text{Rs}\frac{1500}{\text{tonne}} \times 3 \text{ million tonne} = \text{Rs } 4500 \text{ million}$$

$$\text{Waste mining cost} = \frac{500}{m^3} \times 5 \text{ million } m^3 = 2500 \text{ million}$$

$$\text{Ore mining cost } = \text{Rs } \frac{500}{\text{tonne}} \times 3 \text{ million tonne} = 1500 \text{ million}$$

Total cash flow for 1st year = Rs (4500–2500–1500) million

$CF_1 = 500 \text{ million}$

For 2nd year

Ore = 3 million tone

Waste = 5.5 million m^3

Selling price = Rs 1500 × 3 = Rs 4500 million

Waste mining cost = Rs 500 × 5.5 = Rs 2750 million

Ore mining cost = Rs 500 ×3 = Rs 1500 million

Total cash flow for 2nd year = Rs (4500-2750–11500) million

$CF_2 = \text{Rs } 250 \text{ million}$

For 3rd year

Ore = 3 million tone

Waste = 5 million m^3

Selling price = Rs 1500 × 3 = Rs 4500 million

Waste mining cost = Rs 500 × 5 = Rs 2500 million

Ore mining cost = Rs 500 × 3 = Rs 1500 million

Total cash flow for 3rd year = Rs (4500 – 2500–1500) = Rs 500 million

$$\text{NPV} = \text{Initial capital} - \left\{ \frac{CF_1}{(1+i)^1} + \frac{CF_2}{(1+i)^2} + \frac{CF_3}{(1+i)^3} \right\}$$

$$= \text{Rs } 1000 - \left\{ \frac{500}{1+0.1} + \frac{250}{(1+0.1)^2} + \frac{500}{(1+0.1)^3} \right\}$$

$$= \text{Rs } 1000 - \{454.545 + 206.611 + 37.5657\}$$

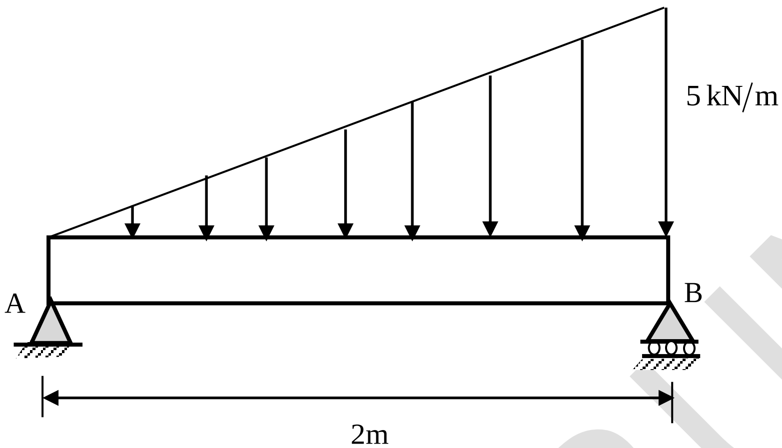
$$= \text{Rs} 1000 - 1036.81$$

$$= -36.81 \text{ million}$$

Since, question is talking about revenue

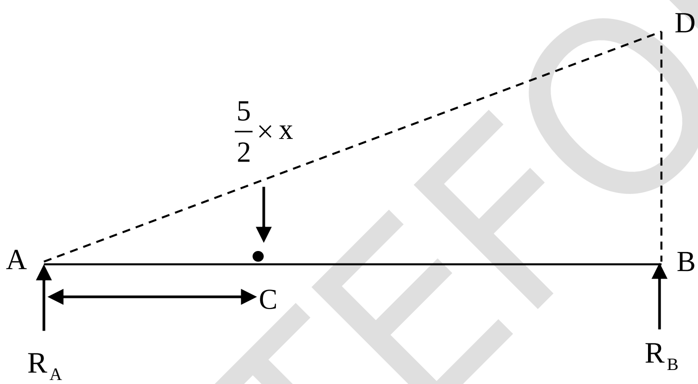
So, NPV = 36.81 million

38. A triangular distributed load is applied on top of a beam as shown in the figure. The value of maximum bending moment in kN-m is __________ (round off to 2 decimal places).



Key: (1.28)

Sol:



Let maximum bending moment occur at C which is x distance from point A

Taking moment along A,

$\Sigma M_A = 0$

$\Rightarrow R_B \times 2 - 5\times\frac{2}{3}\times 2 = 0$

$\Rightarrow R_B = \frac{20}{3\times 2} = \frac{10}{3}\,kN$

Shear force at C = 0

$\Rightarrow \left(5-\frac{10}{3}\right)-\frac{1}{2}+x.\frac{5x}{2}=0$

$\Rightarrow \frac{5}{3}-\frac{5x^2}{4}=0$

$$\Rightarrow \boxed{x = \frac{2}{\sqrt{3}}\,m}$$

Moment about C

$$M_C = \frac{5}{3}\times\frac{2}{\sqrt{3}} - \frac{5}{3}\left(\frac{1}{3}\times\frac{2}{\sqrt{3}}\right)$$

$$= \frac{5}{3}\times\frac{2}{\sqrt{3}}\left(1-\frac{1}{3}\right)$$

$$= \frac{5}{3}\times\frac{2}{\sqrt{3}}\times\frac{2}{3} = \frac{20}{9\sqrt{3}} = 1.28\ \text{kN-m}$$

39. For a dumpy level, the bubble tube has sensitivity of 40" for one division. While taking a staff reading at a distance of 60 m, the bubble is out of centre by 2 divisions. The error in staff in mm is _______ (round off to one decimal place).

Key: (23.27)

Sol: Sensitivity, $\alpha = \frac{3}{nD}$ radian

1 radian = 206265 second

$$\alpha = \frac{S}{nD}\times 206265\ \text{sec}$$

$$S = \frac{nod}{206265} = \frac{2\times 60\times 40}{206265} = 0.02327\ m = 23.27\ mm$$

40. On an old plan of scale 1:1000, leasehold area of a mine is now measured as 802 cm^2 using a planimeter. The plan is found to have shrunk, such that the original line of 10 cm is now measured as 9.8cm on the plan. True lease hold mine area, in m^2, is ____________(round off to the nearest integer).

Key: (83506.87)

Sol: Shrinkage factor $SF = \frac{\text{distance on map}}{\text{corresponding distance on ground}} = \frac{9.8}{10}$

Corrected area $= \frac{\text{measured area}}{(S.F)^2} = \frac{802}{(0.98)^2} = 835.0687\ cm^2$

True mine area $= 835.0687\times(1000)^2\ cm^2 = \frac{835.0687\times 10^6}{10^4}\ m^2 = 83506.87\ m^2$

41. CO is released from a point source on a level ground at a rate of 25 g/s. The average wind speed is 5m/s. The dispersion coefficients are 150 m and 200 m in horizontal and vertical directions, respectively, at a receiver station located on the ground along the downwind direction. Assuming the plume follows Gaussian dispersion model, the concentration of CO, in $\mu g/m^3$, at the station is _________(round off to 2 decimal places).

Key: **(50-55)**

Sol: According to Gaussian dispersion mode

$$C = \frac{\theta}{2\pi \vartheta \sigma_y \sigma_z} = \frac{25}{2\times 3.14\times 5\times 150\times 200} = 26.52\,\mu g/m^3$$

42. Assume that COVID-19 growth rate of number of infections per day (c) in a certain population is represented by the following differential equation.

$$100\frac{dc}{dt} - 7c = 0$$

Where, t stands for time in days. Time taken for the number of infections per day to double, in days, is _____________. (round off to the nearest integer).

Key: **(10)**

Sol: DE $\Rightarrow \frac{dc}{c} - \frac{7}{100}$dt is V.S.F

Integrating, we get

$$\ell nc = \frac{7}{100}t + \underbrace{\ell n(k)}_{\text{constant}}$$

$$\Rightarrow \ell n\left(\frac{c}{k}\right) = \frac{7t}{100} \Rightarrow c = ke^{7t/100} \qquad \ldots(1)$$

Initially (i.e., t = 0) Let $c = c_0$, (1) gives (where c is number of infections)

$c_0 = k$

When $c = 2c_0$ (i.e., double), t = ?, (1) gives

$$2c_0 = k_0 e^{7t/100} \Rightarrow \frac{7t}{100} = \ell n2 \Rightarrow t = \frac{100}{7}\ell n(2) = 9.902 \approx 10 \text{ days}$$

43. Ore is hoisted from 620m depth using a single skip of 7 tonne pay load. The skip winding system has constant acceleration/deceleration of 1 m/s^2 and a constant speed of 10 m/s. The skip loading time and unloading time are 120 s and 60 s, respectively. Considering the overall utilization of the skip as70%, the maximum daily capacity of the winding system, in tonne, is __________(round off to the nearest integer).

Key: **(1250-1350)**

Sol: Depth = 620 mm

Speed, s = 10 m/s

Loading time, LT = 120s

Unloading time UT = 60s

Time taken to hoist 620 m

$$t = \frac{620}{10} = 62\,\text{sec}$$

Total time required to complete one cycle

$$= 62 \times 2 + 120 + 60$$

$$= 304\,\text{sec}$$

Daily capacity $= \frac{7}{304\,\text{sec}} \times 0.7 = \frac{7}{304} \times 24 \times 3600 \times 0.7 = 1392.63$

44. In an analysis of fragmented blast muck, the mean fragment size is found to be 60 cm with uniformly index of 1.25. Considering Rosin-Ramler equation, the cumulative mass fraction, in percent, to pass the grizzly screen size of 100 cm is _________(round off 2 decimal places).

Key: **(71-75)**

Sol: According to Rosin-Rammler equation

$$R = e^{-\left(\frac{x}{x_c}\right)^n}$$

R = proportion of material retained on screen

x = screen size

x_c = characteristic size

N = index of uniformity

Here, $x = 100$

$x_c = 60\text{ cm}$

$n = 1.25$

$$R = e^{-\left(\frac{100}{60}\right)^{1.25}} = 0.15$$

So, % cumulative mass fraction to pass

$$= (1 - R) \times 100\%$$

$$= (1 - 0.15) \times 100\%$$

$$= 85\%$$

45. A single-acting reciprocating ram pump, while running at 120 rpm, delivers water at a rate of 10 litres per second. Considering the ram diameter is 150 mm and stroke length is 300 mm, the volumetric efficiency of the pump, in percent is __________. (round off to one decimal place)

Key: (94)

Sol: $\mu = 120 \text{ rpm}$

$d = 10 \text{ litres/sec}$

$\text{dia} = 150 \text{ mm}$

$L = 300 \text{ mm}$

$$Q = \frac{10}{1000} = 0.01 \, m^3/\text{sec}$$

$$\text{Capacity } = \frac{Ad^2}{4} \times L \times \frac{\text{rpm}}{6}$$

$$= \frac{3.14 \times (0.15)^2}{4} \times 0.3 \times \frac{120}{60}$$

$$= \frac{3.14 \times 0.15^2}{2} \times 0.3$$

$$= 0.010597$$

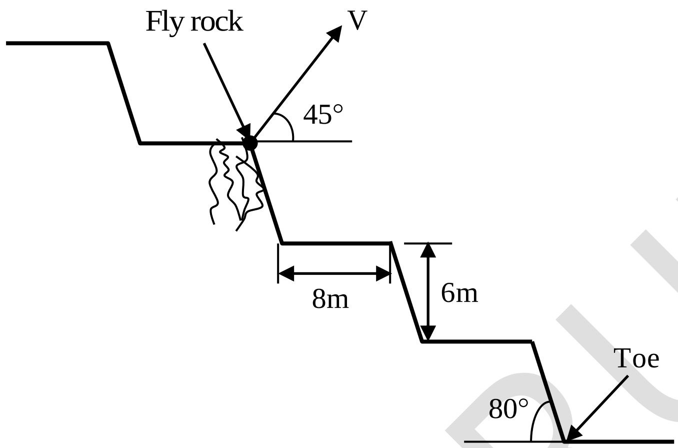
$$\eta = \frac{0.01}{0.010597} = 0.94 = 94\%$$

46. In a sand stowing arrangement, the slurry has a sand concentration of 35% by volume. The specific gravity of sand grain is 2.6. The concentration of sand by weight, in percent, in the slurry is ________ (round off to one decimal place)

Key: (58.83)

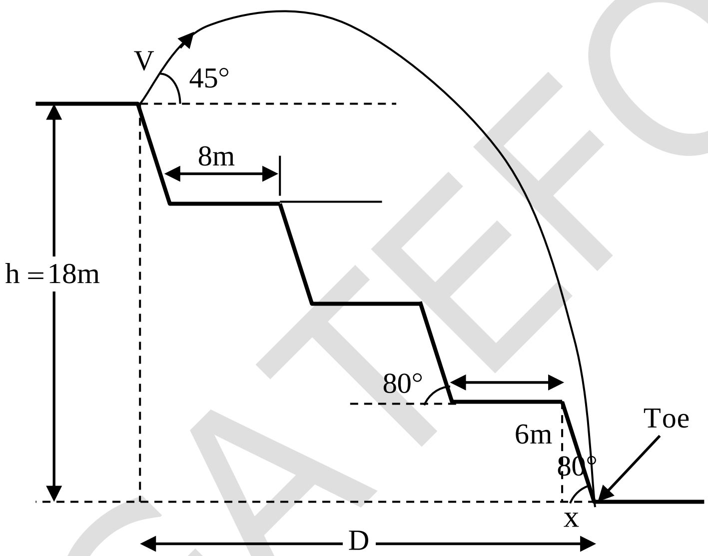
Sol: $$\% \text{ sand by weight } = \frac{W_{sand}}{W_{sand} + W_w} = \frac{2.6 \times 0.35}{2.6 \times 0.35 + 0.65} \times 100 = 58.33\%$$

47. In a surface mine, third bench from the pit bottom is blasted, as shown in the figure. The width, height and slope angle of each bench are 8m, 6m, and 80°, respectively. A fly rock is projected at an angle of 45° with the horizontal with initial velocity, v. If the acceleration due to gravity is 10 m/s^2 then the minimum velocity (v) in m/s required for the fly rock to reach just beyond toe of the pit slope is _________. (round off 2 decimal places)



Key: (10)

Sol:



$$\tan 80° = \frac{6}{x}$$

$$\because x = \frac{6}{\tan 80°}$$

$$D = 8 + 8 + 3x = 16 \times 3 \times \frac{6}{\tan 80°} = 19.174\text{m}$$

Trajectory equation

$$y = (\tan\theta)x - \left[\frac{g}{2(V\cos\theta)^2}\right]x^2$$

Here, $y = 18$ m

$x = 19.174$ m

$$-18 = (\tan 45°)19.174 - \left[\frac{10}{2\left(\frac{v}{\sqrt{2}}\right)^2}\right](19.174)^2$$

$$-(18+19.174) = -\left(\frac{10}{v^2}\right)(19.174)^2$$

$$37.174v^2 = 10\times(19.174)^2$$

$$V^2 = \frac{10\times(19.174)^2}{37.174} = 98.897$$

$$\boxed{V = 9.945 \text{ m/s}}$$

48. Injury experience is studied in an underground coal time with a random sample of 132 workers. The results of the study are tabulated below.

	Injured	**Non-injured**	**Total workers**
Roof-bolter operators	13	12	25
Loader operators	35	75	107
Total workers	48	84	132

The odds ratio of experiencing an injury by the roof-bolter operators when compared to the loader operator is ________ (round off to 2 decimal places).

Key: **(2.22)**

Sol: Odal ratio $= \frac{13\times 72}{35\times 12} = 2.22$

49. A random variable X is defined by

$$X = \begin{cases} -2 & \text{probability } \frac{1}{3} \\ 3 & \text{probability } \frac{1}{2} \\ 1 & \text{probability } \frac{1}{6} \end{cases}$$

The value of $E(X^2)$ is ___________(round off to one decimal place)

Key: **(6)**

Sol: $X = -2, 1, 3 \quad (\text{discrete RV})$

$$\Rightarrow P(X=-2)=\frac{1}{3}; P(X=1)=\frac{1}{6}, P(X=3)=\frac{1}{2}$$

$$\therefore E(X^2)=\sum_x x^2P(x)=(-2)^2\times\frac{1}{3}+1^2\times\frac{1}{6}+3^2\times\frac{1}{2}=\frac{8+1+27}{6}=6$$

50. A project network consists of the following activities

Activity	Immediate predecessors	Duration (days)
A	–	3
B	–	4
C	A, B	5
D	B	6
E	D	7
F	C,E	8
G	D	9
H	F, G	X

If the project completion time is 30 days, then the value of 'X', in days, is __________. (in integer)

Key: **(5)**

51. Rate of fuel consumption f_c (litres per hour) of a truck varies with truck speed x, (kmph) as given below

$$f_c=20+\frac{x^2}{50}$$

The fuel price is Rs. 70 per litre. Other costs amount of Rs. 500 per hour. If the truck travels 100 km from a coal mine to a thermal plant, the speed of the truck, in kmph, that minimizes the total cost is __________ (round off to one decimal place)

Key: **(36.84)**

Sol: $f_c=20+\frac{x^2}{50}$

$$\text{Total cost }=\frac{100}{x}\left(20+\frac{x^2}{80}\right)\times 70+\frac{100}{20}\times 500=\frac{190000}{x}+140x$$

$$\frac{\partial T_C}{\partial x}=\frac{-190000}{x^2}+140$$

Minimize $T_c=0$

$$\frac{-190000}{x^2}=-140$$

$\Rightarrow x' = 1357.1428 \Rightarrow x \pm 36.84\ \text{km/hr}$

$$TC'' = \frac{-19000}{x^3} \times (-2) = \frac{190000 \times 2}{x^3} = \frac{380000}{x^3}$$

$TC''(\text{at } x = +36.84) = 7.6$

$TC''(\text{at } x = -36.84) = -7.6$

For minimum $T.C'' > 0$

$\therefore x = 36.84\ \text{km/hr}$

Velocity of vehicle = 36.84 km/hr

52. A cement company has three factories which transport cement to four distribution centres. The daily production of each factory, the demand at each distribution centre, and the associated transportation cost per tonne from factory to distribution centre are given in the Table.

Distribution centre

Factory		D_1	D_2	D_3	D_4	Supply (tonnes/day)
	F_1	20	30	110	70	600
	F_2	10	0	60	10	100
	F_3	50	80	150	90	1000
	Demand (tonnes/day)	700	500	300	200	

The initial basis feasible solution using the least-cost rule is ___________(in integer).

Key: (112000)

Sol:

	D_1	D_2	D_3	D_4	Supply
F_1	20	30	110	70	600
F_2	10	0	60	10	100
F_3	50	80	150	90	1000
Demand	700	500	300	200	

From least-cost metro

Solution start from least value

	D_1	D_2	D_3	D_4	Supply(+/day)
F_1	20	30	110	70	600
F_2	10	0	60	10	100
F_3	50	80	150	90	1000
Demand (+/day)	700	500	300	200	

$\text{Cost} = 20\times600+0\times100+50\times100+80\times400+150\times300+90\times200=112000$

53. The grade-tonnage distribution for the ultimate pit of a mine is given below.

Cu grade (%)	**Cumulative million tonnes below the grade**
0.1	0
0.4	15.0
0.5	17.0
0.6	18.0
0.7	19.0
0.9 and above	23.0

The mill cut-off grade is 0.5% Cu. The annual mining capacity (ore + waste) is 4.5 million tonne and milling capacity is 1.0 million tone. Excavation is planned in such a ways that either of the mine or the mill runs at full capacity throughout. The planned life of the mine, in years, is __________(round off to one decimal place)

Key: **(6)**

Sol: Total cumulative million tonnes (ore + waste) = 23

Life of mine run at capacity $=\frac{23}{4.5}=5.11$ years

As, millo cut of grade = 0.5% cu

Above this grade, excavation is useful

Total excavation for milling = 4+ 1 + 1 = 6 tonnes

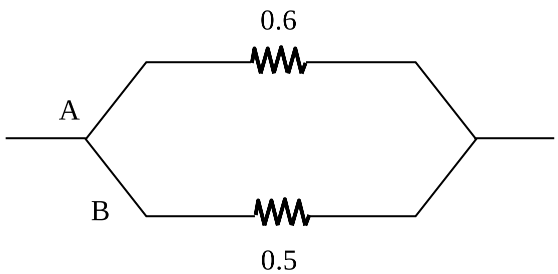
Lift of mill-run at full capacity $=\frac{6}{1}=6$ years

Here, planned life of the mine $= 6$ years.

54. A coal mine operating in three shifts produces 400 tonnes of coal per day with a face OMS of 1.0 from panel A, and 200 tonnes of coal with face OMS of 1.0 from panel B. The panel A and panel B are in parallel with resistance 0.6 $Ns^{-2}m^{-8}$ and 0.5 $Ns^{-2}m^{-8}$, respectively. If the panels are supplied with minimum permissible quantity as per CMR 2018, the requisite regulator resistance to meet the conditions in $Ns^{-2}m^{-8}$ is _________(round off to 2 decimal place)

Key: **(1.9)**

Sol:



As per CMR 2018,

Maximum quantity of air per form of daily output is 2.5 m^3/min

So, for panel A, $q_A = \dfrac{400 \times 2.5}{60} m^3/s = 16.67\ m^3/s$

For panel B $q_B = \dfrac{200 \times 2.5}{60} m^3/s = 8.33\ m^3/s$

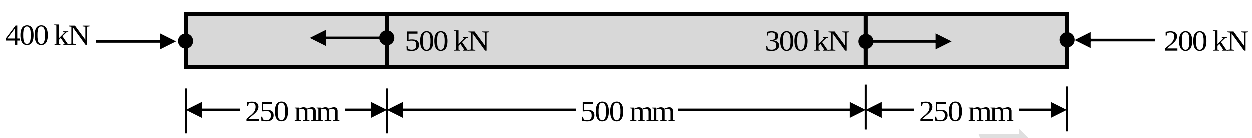
So, regulator will placed on panel B, having resistance 'R_r'

Since, Panel A and Panel B are in parallel, so pressure will be same

$$P = RQ^2$$
$$R_A q_A^2 = (R_B + R_r) q_B^2$$
$$0.6 \times (16.67)^2 = (0.5 + R_r)(8.33)^2$$
$$166.733 = (0.5 + R_r)(69.3889)$$
$$\Rightarrow 2.4028 = 0.5 + R_r$$
$$\therefore R_r = 2.4028 - 0.5 = 1.9$$

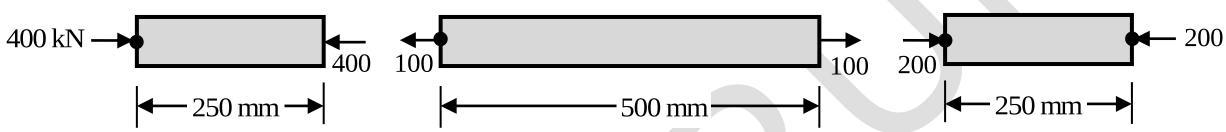
Hence, resistance of regulator = 1.9 $Ns^{-2}m^{-8}$

55. A set of three steel bar of equal cross-sectional area of $0.01\,m^2$ are loaded, as shown in the figure. The elastic modulus of steel is 200 GPa. The overall change of length of the complete set of bars, in mm, is ____________ (round off to 3 decimal places).



Key: **(0.05)**

Sol:



Area, $A = 0.01\,m^2$

$E = 200 \times 10^9\ N/m^2$

For steel bus A (compression)

$$E = \frac{\frac{P}{A}}{\frac{\Delta L}{L}} \Rightarrow \frac{\Delta L}{L} = \frac{P}{AE} \Rightarrow AL = \frac{PL}{AE}$$

Compression

$$\Delta L_A = \frac{-400 \times 250 \times 10^{-3}}{0.01 \times 200 \times 10^9} m = -\frac{400 \times 250 \times 10^2}{200 \times 10^3} m = -0.05\ mm$$

For steel base B (expansion)

$$\Delta L_B = \frac{100 \times 500 \times 10^3}{0.01 \times 200 \times 10^3} mm = 0.025\ mm$$

For steel base (compression)

$$\Delta L_C = \frac{200 \times 10^3 \times 250}{0.01 \times 200 \times 10^3} = -0.025\ mm$$

Sign convection: Compression (-ve) and expression (+ve)

Overall change in length $= = (-0.05 + 0.025 - 0.025)\,mm = -0.05\ mm$